INTERTIDAL MACROPHYTES of SANTA CRUZ ISLAND, CALIFORNIA

Kirk Apt, Carla D'Antonio,
James Crisp, and Joyce Gauvain

The Herbarium
Department of Biological Sciences,
University of California, Santa Barbara
Publication Number 6
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Cover: A view northward from vicinity of Fraser Point, west end of Santa Cruz Island.

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FOREWORD

Manuscripts accepted for presentation in the Publication Series of the Herbarium, Department of Biological Sciences, University of California, Santa Barbara (UCSB), include primarily those with a floristic emphasis and those for which voucher specimens are deposited at UCSB. This endeavor is consistent with the goals of the UCSB Herbarium, summarized as follows: 1) to maintain a botanical collections repository; 2) to function as a research facility within the Department of Biological Sciences; 3) to provide educational programs; and 4) to provide botanical services.

UCSB Herbarium Publication Number 6, Intertidal Macrophytes of Santa Cruz Island, California, is a product of research conducted by herbarium associates. The field work was funded by the University of California Natural Reserve System (NRS), and received logistical and staff support from the System's Santa Cruz Island Reserve (SCIR). This publication combines original research and compilation of existing information. It provides the most complete evaluation of intertidal macrophytes for the California Islands to date, especially for Santa Cruz Island. The authors are confident that this work will constitute a sound foundation for future research.

The NRS is a statewide system of habitat reserves administered by the University of California. It's purpose is to maintain examples of California's ecological diversity to be used for research or teaching. The SCIR (formerly Channel Islands Field Station, 1966-1976) was organized to provide access, assistance, and facilities to researchers and classes for studies on the archaeology, marine and terrestrial biology, geography, and geology of Santa Cruz Island. The Reserve Field Station, located centrally on Santa Cruz Island, continues to serve researchers and classes from the University of California, and groups from other institutions who are investigating island phenomena. The primary purpose of this field station has been to provide room and board facilities, as well as transportation about and around the island (land

and nearby waters). Modest working space, lab equipment, reference collections, and library materials are available.

The Santa Cruz Island Reserve is operated under a lease agreement with The Nature Conservancy (TNC). Similar cooperative agreements are in effect between TNC and NRS throughout the state. The Nature Conservancy is an international membership organization committed to the global preservation of natural diversity. Its mission is to find, protect and maintain the best examples of communities, ecosystems and endangered species in the natural world. To date the Conservancy and its members have been responsible for the protection of nearly three million acres in fifty states, Canada, Latin America, and the Caribbean. While some areas are transferred for management to other conservation groups, both public and private, the Conservancy owns and manages some nine hundred preserves--the largest privately owned nature preserve system in the world.

The Nature Conservancy acquired a partial interest in Santa Cruz Island in 1978 and assumed full ownership for the western 90% of Santa Cruz Island in 1987. The Conservancy's primary goal for the island is to preserve and, where possible, restore its unique biological diversity.

The NRS periodically publishes or supports documents about its reserves. Intertidal Macrophytes of Santa Cruz Island, California is NRS Contribution No. 14, and Santa Cruz Island Reserve Contribution No. 1.

Wayne R. Ferren, Jr.
Curator of the Herbarium

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THE INTERTIDAL MACROPHYTES

View southeastward from Coches Prietos, Santa Cruz Island.

INTRODUCTION

The Northern Channel Islands, off the coast of southern California, are a unique resource for the study of marine organisms because these islands are near Point Conception (34°27'N), an area that has long been recognized as an important distributional boundary between northern cold-temperate and southern warm-temperate regions (see Murray et al. 1980 for a review). Portions of the mainland coastline of this region are influenced heavily by urban and oil development. The islands of the region, however, contain the most undisturbed sections of coastline remaining in southern California (Murray et al. 1980). The recent acquisition of several of the islands by the National Park Service and The Nature Conservancy has insured the protection of these highly important coastlines and habitats.

In spite of the unique location and pristine condition of the Northern Channel Islands, there have been few thorough studies of their intertidal biota. Notable exceptions include Littler (1977, 1978, 1979, 1980) and Murray et al. (1980). Such surveys are important because they provide baseline information for the evaluation of human impacts on the environment, and of changes that may result from climatic anomalies such as El Niño, a periodic phenomenon with unusually high water temperatures.

Santa Cruz Island is centrally located within the Northern Channel Islands (Fig. 1A) and is thought to be influenced by both cold and warm water currents (Cockerell 1939, Neushul et al. 1967, Seapy and Littler 1980, and Murray et al. 1980). The island also is large (249 km^2, 30 km in length) and geologically, topographically, and microclimatically diverse. Its intertidal marine flora is known incompletely and has been surveyed extensively only at two sites: Prisoners' Harbor and Willows Anchorage (Littler 1977, 1978, 1979). Santa Cruz Island is used extensively by researchers and classes, and is included in the Natural Reserve System of the University of California.

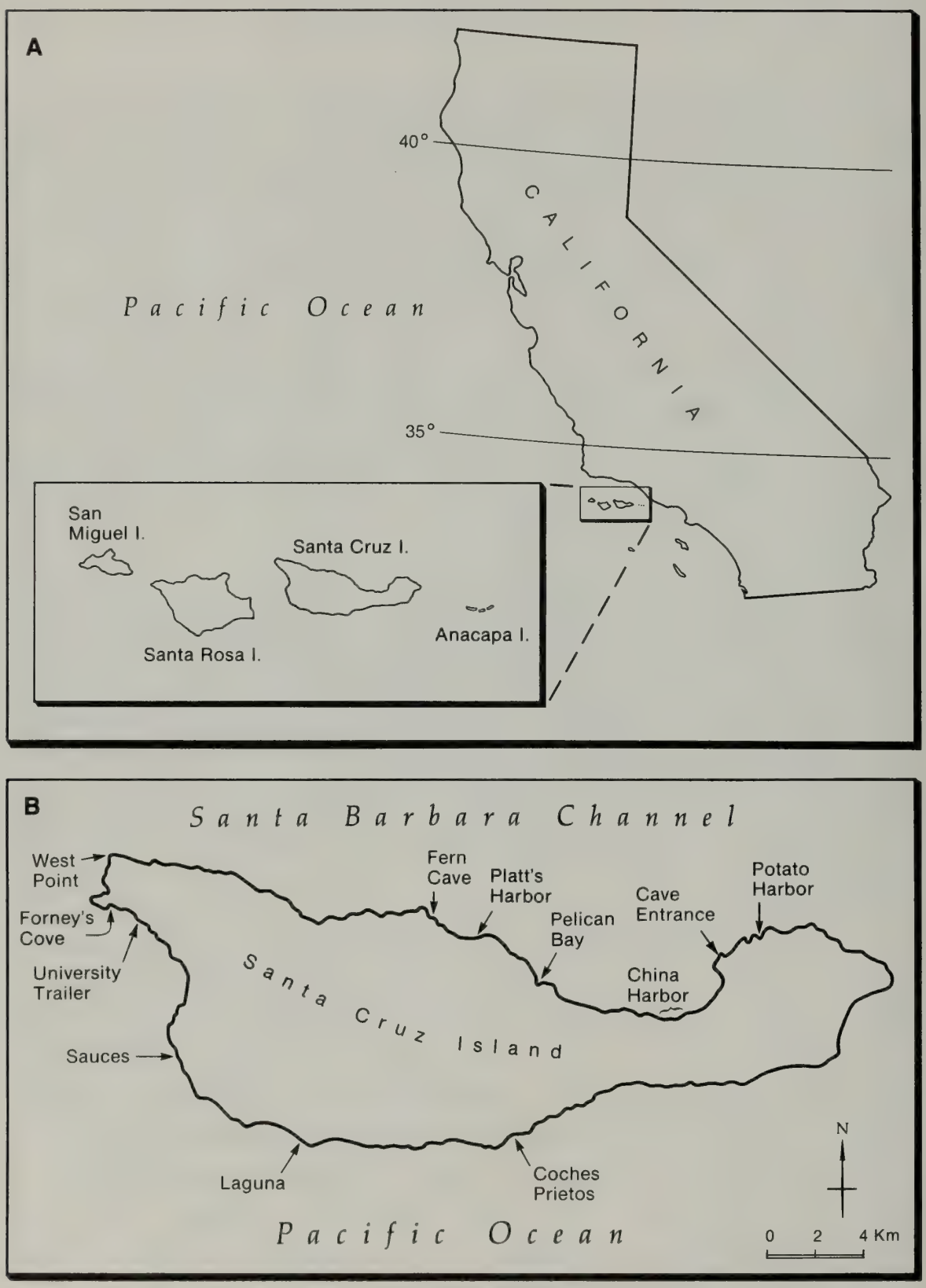

Figure 1. A. Location of Santa Cruz Island; B. Location of intertidal sites surveyed for marine macrophyte species.

This study provides an in-depth analysis of the intertidal marine macrophytes, both algae and marine angiosperms, of Santa Cruz Island with an accompanying collection of voucher specimens from numerous, diverse sites on the Island. The resulting flora was evaluated in terms of its relationship to northern and southern intertidal floras. Species lists from each site were compared for biogeographic patterns. This work also includes photographs and descriptions of some of the algae that are difficult to identify, and a compilation of all marine macrophytes reported from Santa Cruz Island.

MATERIALS AND METHODS

A series of study sites was chosen to represent different geographic regions of Santa Cruz Island. This series included ten major sites and two caves (Fig. 1B) that characterized northern, western, and southern sections of coastline. The western and southern sites were approached by land, whereas the northern sites were reached by inflatable boat. The eastern portion of the island was not accessible.

Our sites varied in the extent of intertidal habitats, rock type, abundance of abalone, and degree of exposure to ocean swell and are considered representative of Santa Cruz Island. A qualitative evaluation of these features was made at the time of sampling. We did not survey Prisoners' Harbor and Willows Anchorage, because these sites were surveyed intensively by Littler (1979).

During the summers of 1985 and 1986, examination of each site was conducted by three or four individuals who searched a 30-100 m strip of coastline (topography permitting) for two to three hours during a minus low tide. Each investigator collected samples of all non-crustose species of algae encountered, and also recorded notes on the general abundance of each species. This method was effective in maximizing the number of taxa found.

Upon returning to the Reserve Field Station, specimens were pressed or preserved in liquid as needed. Each species was placed into one of

four categories based on its abundance at a site. They were listed as rare, if less than four specimens were seen by all investigators; occasional, if between four and twenty specimens were encountered; common, if the species was regularly encountered but did not occupy more than twenty-five percent cover in the zone where it occurred; and abundant, if the species was encountered regularly and occupied more than 25% cover within its zone.

Upon returning to the laboratory at UCSB, we reexamined all specimens to confirm field identifications. Specimens also were compared with those in the herbaria of Hopkins Marine Station at Monterey and the University of California at Berkeley. Taxonomically difficult specimens were sent to experts (Drs. I. Abbott, D. Kapraun, and J. Norris) for verification. Nomenclature generally is consistent with Abbott and Hollenberg (1976), with exceptions treated in Abbott (1985), Druehl (1979), Gabrielson (1982), Guiry et al. (1984), Hawks and Scagel (1986), Huisman (1985), and Silva et al. (1987).

Species lists for each site were entered into a database and analyzed using TWINSPAN and DECORANA, two multivariate techniques. TWINSPAN is a divisive technique that classifies units (i.e., sites) according to indicator species. It is used commonly in vegetation sampling (Goldsmith et al. 1986) and produces a table from which a dendrogram can be constructed. DECORANA is an ordination technique that arranges samples spatially along principal axes (constructed from the species composition data) to reflect their similarity. This technique was developed by Hill (1979) and also is used commonly for vegetation analyses. DECORANA analyses were conducted using both presence/absence data and a numerical or scaled approximation for our subjective frequency classifications. TWINSPAN analyses were conducted only on presence/absence data.

For the purposes of interpreting trends in our data, we classified species as either northern, southern, or widely distributed according to records published in Abbott and Hollenberg (1976). We define a northern species as one that reaches its southern distributional limit in the

region between Point Conception and the Mexican border. We define a southern species as one that is more typical of southern California and Mexican waters and reaches its northern limit in the region of Point Conception or southward. We define a widely distributed species as one that occurs throughout northern and southern California.

SITE DESCRIPTIONS

In the following section, we provide detailed descriptions of the physical and biotic characteristics of each study site. A summary of substrate type, topography, and abalone occurrence for the 10 sites and two caves is presented in Table 1.

WEST POINT--This site occurs at the extreme northwest point of land on the island. The intertidal areas are located at the base of vertical cliffs 30-100 m high, and are exposed directly to ocean swells. Two nearby localities were sampled. The first consisted of a small cave about 100 m east of West Point, with large stable boulders 1-3 m in diameter present inside and outside of the cave. The other site was a small unnamed cove immediately south of West Point. The topography in the cove varied from a boulder beach at the back to near vertical walls with narrow shelves 1-3 m above the low waterline. The shelves contain several large tidepools, and the low intertidal zone was narrow because of the steep topography.

No individual algal species occurred in high abundance at this site, and overall species richness was relatively low. The site contained unique species (e.g., Callithamnion pikeanum, Odonthalia floccosa) that are discussed in more detail later. The high intertidal zone was characterized by the common occurrence of Porphyra perforata and Endocladia muricata, with occasional thalli of Callithamnion pikeanum, Nemalion helminthoides, Mastocarpus papillatus, and Rhodoglossum affine. A number of tidepools occurred in the high intertidal and splash zones, which typically had Bryopsis corticulans and Ulva lobata present.

Table 1. General Characteristics Of Sites Surveyed For Intertidal Macroflora During This Study. Locations are shown in Figure 1. Key: SCV-1 = Santa Cruz Island Volcanics (basalt with breccias). SCV-2 = S.C.I. Volcanics (andesite with breccias). SCV-3 = S.C.I. Volcanics (andesite with sandstones). VS = Volcanic conglomerates with sandstones. BV = Blanca Volcanics (breccias with boulder conglomerates and basaltic sills). MS = Monterey Formation shales.

Site Name	Rock Type	Topography	Abalone
Forney's Cove	SCV-1	Reefs/Boulders	Rare
Univ. Trailer	SCV-1	Reefs	Common
Sauces	VS	Reefs/Boulders	Absent
Laguna	BV	Reefs	Absent
Coches Prietos	BV	Reefs	Rare
Potato Harbor	MS	Reefs/Boulders	Occasional
China Harbor	MS	Reefs/Boulders	Common
Pelican Bay	SCV-3	Reefs/Boulders	Rare
Platt's Harbor	SCV-2	Boulders	Common
West Point	SCV-2	Reefs/Boulders	Rare
Fern Cave	SCV-2	Vertical Cliffs	Absent
Cave Entrance	SCV-2	Vertical Cliffs	Absent

The mid-intertidal was characterized by tufts of Corallina vancouveriensis and Gelidium coulteri, with occasional thalli of Codium fragile, Odonthalia floccosa, and Gigartina spp. The low-intertidal zone had the greatest richness and was dominated by Laminaria setchellii, Eisenia arborea, Bossiella spp., and Prionitis lanceolata. Other common algal species included Plocamium violaceum, Iridaea cordata, and Macrocystis pyrifera.

FORNEY'S COVE--Forney's Cove is a large, protected anchorage immediately southeast of Fraser Point at the west end of the island. The area sampled was a long rocky point immediately adjacent to the west side of the beach. The point consisted of a rock shore with boulders, tidepools, and rock shelves that terminated in a large rock outcrop

approximately 100 m from shore. The exposed horizontal intertidal area averaged about 15 m. There were numerous tidepools, many of which were lined with a thin layer of coarse sand. Rocks in the low intertidal zone often were buried in sand. Wave action was moderate in the outermost portion of the site, and fairly calm at the inner area.

This site had a number of abundant algal species and a high species richness, although it contained only two unique species. These were Nienburgia andersoniana and Platythamnion recurvatum. The common algal species of the high intertidal were Porphyra perforata, Mastocarpus papillatus, Endocladia muricata, Ulva californica, and Hesperophycus harveyanus.

The mid-intertidal was characterized by an abundance of Gigartina canaliculata, Corallina vancouveriensis, and Pelvetia fastigiata. Other common species were Colpomenia sp., Gigartina leptorhynchos, and Centroceras clavulatum.

The low-intertidal zone consisted of an overstory of Egregia menziesii, Phyllospadix torreyi, and P. scouleri. The algal understory was comprised of Lithothrix aspergillum, Bossiella orbigniana, Corallina officinalis, Plocamium cartilagineum, Prionitis lanceolata, Halidrys dioica, Gigartina spp. and Laurencia spp.

UNIVERSITY TRAILER--The area sampled is immediately below and south of the University research trailer, about 1.5 km southeast of Forney's Cove. The coastline consisted of low cliffs up to 10 m high, with extensive rocky shelves at the base (Fig. 2). A 200 m stretch of shoreline was sampled, which included a large number of habitats such as tidepools, small sand beaches, and exposed ledges. In many places, the low-intertidal zone dropped off sharply to a depth of about 3 m.

This site had a relatively high species richness and was similar in species composition to Forney's Cove. Overall, however, it had lower algal cover, more abalone, and fewer areas of sand accumulation than the cove.

Fig. 2. UNIVERSITY TRAILER SITE. This site is below the University research trailer, about 1.5 km southeast of Forney's Cove at the west end of Santa Cruz Island. The coastline is very irregular with a large number of habitats, including tidepools, small sand beaches, and exposed ledges.

Fig. 3. SAUCES SITE. This site is at the mouth of Cañada de los Sauces, on the west side of Santa Cruz Island. The coastline we sampled consisted of large stable boulders and small rocky reefs. The low intertidal is strongly influenced by sand, and many boulders are partially buried.

The high intertidal zone was a mixture of Endocladia muricata, Porphyra perforata, Ulva californica, Mastocarpus papillatus, and Hesperophycus harveyanus. Commonly occurring thalli in the mid-zone were Corallina vancouveriensis on emergent substrate, and Cladophora columbiana and Colpomenia sinuosa in pools. There were occasional thalli of Pelvetia fastigiata, Codium fragile, Gigartina spp., and Gastroclonium subarticulatum. Macroalgae were sparse in much of the low and mid-intertidal zones, possibly as a result of grazing by locally abundant abalone.

The low intertidal zone was dominated by Eisenia arborea, Halidrys dioica, and Bossiella orbigniana. Prionitis lanceolata, Egregia menziesii, Lithothrix aspergillum, and Calliarthron tuberculosum were found occasionally.

SAUCES--This site is at the mouth of Cañada de los Sauces, on the southwest side of the island. A large sand beach about 200 m long separated rocky areas at the north and south sides of the cove. Both of these rocky areas were sampled. The northern section consisted of large stable boulders and small rocky reefs (Fig. 3). The low intertidal was influenced strongly by sand, and many boulders were partially buried. The southern portion of this site also was influenced by sand, and appeared to be exposed more directly to ocean swell.

The rocky intertidal zone at this beach had an intermediate level of species richness, and algal cover was high. Three species were found solely at this site, but overall the flora was most similar to that of the other west-end sites (Forney's Cove and University Trailer).

The high intertidal zone consisted of Porphyra perforata, Endocladia muricata, Mastocarpus papillatus, and Ulva californica, all of which were common. Abundant algal species of the mid-intertidal zone were Corallina vancouveriensis and Gigartina canaliculata. Commonly found species included Gigartina leptorhynchos, Gymnogongrus leptophyllus, Cryptopleura spp., Microcladia coulteri, Gelidium coulteri, and Chaetomorpha linum. The low intertidal zone had an overstory of Egregia menziesii, and

Phyllospadix sp., with Smithora naiadum as a common epiphyte. The lush understory was characterized by patches of Gigartina spinosa, Plocamium cartilagineum, Gracilaria pacifica, Gigartina volans, Bossiella orbigniana, Iridaea cordata, Grateloupia doryphora, and Prionitis lanceolata.

LAGUNA--This site is at the mouth of Laguna Canyon on the southern extreme of Santa Cruz Island. A large sand beach about 100 m long was present with rocky areas occurring on both sides. Sampling was concentrated on the west side of the site; however, a 10-20 m section of shoreline also was sampled on the eastern side. The site was subject to heavy wave action, and sampling was difficult at all times. The intertidal area had a moderate to steep slope and, including the splash zone, encompassed 10-15 m. Only about 50 m of shoreline could be sampled effectively. Numerous sandy pools were present.

This site was characterized by a low species richness, and low abundance levels for those species found. Many large macroalgal species were conspicuously absent, and filamentous algae predominated.

The high intertidal zone had a scattered cover of Endocladia muricata and Porphyra perforata, with occasional thalli of Nemalion helminthoides and Cladophora columbiana. The common occurrence of numerous Polysiphonia and Ceramium spp. in the mid-intertidal zone was unusual. Other common though not abundant species were Ulva lobata, Chaetomorpha linum, Gelidium coulteri, Rhodoglossum affine, Grateloupia doryphora, Gigartina leptorhynchos, and Enteromorpha sp.

The low intertidal was populated sparsely with Prionitis lanceolata and Halidrys dioica. Bossiella orbigniana, Iridaea heterocarpa, and Gastroclonium coulteri were occasional.

COCHES PRIETOS--This site is a small cove on the south-central to southeastern portion of Santa Cruz Island. The rocky intertidal included two areas separated by a small sandy beach. Both rocky areas were sampled. The western side of the cove was characterized by extensive

rocky reefs with several tidepools. The eastern side of the cove consisted of large stable boulders and rock ledges. Overall, about 150 m of shoreline were sampled.

Coches Prietos had a relatively high species richness and a lush algal cover. Common components of the high intertidal zone were Endocladia muricata, Nemalion helminthoides, and Cumagloia andersonii. The mid-intertidal zone was characterized by dense turfs of Gelidium coulteri, Colpomenia sinuosa, Gigartina leptorhynchos, and Cladophora columbiana. A filamentous turf understory composed of Centrocerus clavulatum and Ceramium spp. was also common.

Eisenia arborea and Phyllospadix sp. were common overstory plants in the low intertidal zone. Sargassum muticum, a species naturalized from Japan, also was common. Understory species included Lithothrix aspergillum, Halidrys dioica, Scytosiphon lomentaria, Gigartina spinosa, Corallina officinalis, Pterocladia capillacea, and Laurencia spp., all of which were common.

POTATO HARBOR--This site is a sheltered cove on the northeastern portion of Santa Cruz Island. The area sampled included a boulder beach, a moderately sloping shelf, and a boulder field near the mouth of the cove. The shelf (Fig. 4) contained numerous tidepools. About 100 m of shoreline was sampled. The high intertidal zone was characterized by scattered patches of Mastocarpus papillatus, Endocladia muricata, and Nemalion helminthoides.

The most abundant alga in the mid-intertidal zone was Corallina vancouveriensis. Other common species included Gigartina canaliculata, Codium fragile, Gelidium coulteri, and Rhodoglossum affine. In contrast with other sites, invertebrates such as chitons, limpets, sea urchins, and mussels also were common.

The overstory in the low intertidal was composed of Eisenia arborea, Macrocystis pyrifera, Egregia menziesii, and Phyllospadix sp. The understory was a well developed turf of Bossiella orbigniana, Laurencia

spp., Gigartina spp., Gelidium robustum, Prionitis lanceolata, and Halidrys dioica.

CAVE ENTRANCE--This site is at the mouth of a cave between Potato Harbor and China Harbor. The vertical walls of the cave were sampled.

The cave entrance was characterized by a poorly developed high and mid-zone flora dominated by crustose algae and invertebrates. Characteristic low zone species were Rhodymenia californica and Plocamium cartilagineum. Less common species were Plocamium violaceum and Callophyllis violacea.

CHINA HARBOR--This site is a large north-facing bay on the north side of Santa Cruz Island. The intertidal (Fig. 5) consists of low gradient boulder and cobble fields, with small bedrock outcrops. The sites sampled were primarily on the west side of the harbor below the access road. About 200 m of shoreline was sampled.

The high intertidal zone throughout this site was sparsely populated with Ulva californica and Enteromorpha sp. The mid-intertidal zone consisted of a mixture of Corallina vancouveriensis, Colpomenia sinuosa, Leathesia difformis, Laurencia pacifica, and Gigartina canaliculata. Cryptopleura was a common epiphyte, particularly on Corallina. Algal cover, however, was low in the mid-zone in the boulder portion of the site, perhaps because abalone, which graze macrophytes, were abundant on large boulders. Small boulders appeared to be disturbed by wave action.

The algal overstory in the low intertidal zone was composed of abundant quantities of Sargassum muticum, with patches of Phyllospadix. Both species were covered with epiphytes. The understory included tufts of Pterocladia capillacea and Gelidium robustum. Herposiphonia verticillata was an abundant epiphyte on a number of algae, particularly corallines. Other commonly occurring species were Gigartina spinosa, Pachydictyon coriaceum, Laurencia pacifica, Hypnea valentiae, and Dictyota flabellata. Acrosorium uncinatum and Callithamnion rupicolum also were common epiphytes on a variety of algae.

Fig. 4. POTATO HARBOR SITE. This site is a sheltered cove on the northeastern shoreline of Santa Cruz Island. The area is predominately a narrow, irregular, moderately sloping shelf of Monterey Shale.

Fig. 5. CHINA HARBOR SITE. This site is a large north-facing bay on the north side of Santa Cruz Island. The intertidal zone consisted of low-gradient boulder and cobble fields, with small rocky outcroppings.

PELICAN BAY--This site is in a protected cove on the northern shore of Santa Cruz Island. The intertidal zone consists of a near-horizontal bench rising abruptly into near-vertical cliffs. There were numerous tidepools on the bench, the edge of which dropped off steeply into approximately 5 m depth. We sampled from the center of the cove, along the eastern side to the outside of the cove, a distance of about 75 m. Included with this site was a small, stable boulder field about 200 m east of Pelican Bay.

Pelican Bay had the highest species richness of all the sites. Several species were found only at this site. These were Amphiroa zonata, Gymnothamnion elegans, Iridaea flaccida and Pterochondria woodii. Algal cover was generally high, particularly in the low and mid- zones.

The high intertidal zone was dominated by Pelvetia fastigiata. Other common species were Endocladia muricata, Mastocarpus papillatus, and Nemalion helminthoides. The mid-zone had a number of abundant algal species, including Codium fragile and its epiphyte Ceramium codicola, and Gelidium coulteri, Corallina vancouveriensis, and Gigartina canaliculata. Other commonly occurring species included Enteromorpha sp., Colpomenia sinuosa, Rhodoglossum affine, and Gelidium purpurascens. The low intertidal zone had an overstory that included Egregia menziesii, Macrocystis pyrifera, Eisenia arborea, and Phyllospadix sp. The understory was algal turf composed of Laurencia pacifica, Bossiella orbigniana, Gigartina spp., Rhodymenia californica, Chondria californica, Prionitis lanceolata, Calliarthron tuberculosum, and Plocamium violaceum.

PLATT'S HARBOR--This site, on the north side of Santa Cruz Island, is difficult to reach from land because it lies at the base of near vertical cliffs. The main sampling area included approximately 60 m of shoreline with medium to large unstable boulders and a narrow wave-swept bench to the east of the harbor. Both areas received moderate wave action.

This site had relatively low species richness, as well as generally low algal cover. Endocladia muricata was abundant in the high intertidal zone, interspersed with Mastocarpus papillatus and Nemalion helminthoides. Common mid-zone algae were Gigartina canaliculata, Gelidium coulteri, Corallina vancouveriensis, and Rhodoglossum affine. A broad band of mussels (Mytilus californicanus) dominated the low and mid-zones of the bench.

A dense overstory of Egregia menziesii occurred in the low intertidal zone, with occasional patches of Eisenia arborea and Phyllospadix. The most abundant understory species was Bossiella orbigniana. Other common species were Gigartina spinosa, Halymenia californica, Pachydictyon coriaceum, Halidrys dioica, Laurencia pacifica, and Prionitis lanceolata.

FERN CAVE--This cave is located in the back of a cove just east of Diablo Point. The mouth of the cave, about 4 m across, is blocked by several large boulders, the tops of which were exposed at low tide. The cave extends back about 10 m. Boulders in the bottom of the cave were submerged completely. Non-crustose species were present only near the entrance to the cave, so we concentrated sampling in this area.

Cladophora graminea, Plocamium cartilagineum, Bossiella orbigniana, Gigartina exasperata, and the epiphyte Herposiphonia verticillata were common in the low intertidal zone near the cave entrance. Unidentified coralline crusts covered the rock surfaces throughout the low and mid-zones.

ANALYSIS OF THE INVENTORIES

We identified and determined the relative abundance of 154 species from the 12 sites (Table 2). Appendix I contains the complete catalog of species collected during this study. Thirty-four species, or about 25% of the total, were new records for Santa Cruz Island (Table 3). Sixty-three percent of the new records are for widely distributed species (Abbott and Hollenberg 1976). Because previous sampling of intertidal macrophytes has been restricted to a few locations, the increase in total number of taxa probably is due to the increased sampling effort rather than recent changes in species distributions. As a result of this study and the work by Littler, intertidal species reported from Santa Cruz Island now number 170. To date, a total of 280 marine macrophytes have been collected or reported from the intertidal zone and the subtidal region off Santa Cruz Island. Appendix III contains a checklist of published records for the combined list.

In spite of the large number of locally rare species, the general appearance of all sites was similar. A typical intertidal area was composed of a sparsely populated high intertidal region with a low species richness. Common high intertidal algae included Endocladia muricata, Porphyra perforata, Ulva californica, Mastocarpus papillatus, and Nemalion heminthoides. The mid-intertidal zone typically consisted of such species as Gelidium coulteri, Gigartina canaliculata, Gigartina leptorhynchos, Rhodoglossum affine, Corallina vancouveriensis, and Cryptopleura spp. This region included many marine invertebrates such as mussels, barnacles, and abalone. Grazing by the latter animal probably influenced the species of algae present. The low zone typically contained Prionitis lanceolata, Laurencia spp., Gelidium robustum, Bossiella sp., Corallina officinalis, Gigartina spinosa, Phyllospadix spp., and at least one large brown alga, usually Egregia menziesii or Eisenia arborea.

The number of species varied greatly among sites (Table 4). Of the major sites visited, those most exposed to wave action (Laguna, West Point, and Platt's) with less accessible intertidal area had the lowest

Table 2. Distribution And Relative Abundance Of Intertidal Macrophytes At The Sites Sampled On Santa Cruz Island. Species are listed alphabetically by division. The relative abundance values are equivalent to terms used in the text. 1 = rare, 2 = occasional, 3 = common, and 4 = abundant. The site codes are also equivalent to those in the text. Where NW = Northwest Point, FC = Forney's Cove, UT = University trailer, SA = Sauces, LA = Laguna, CP = Coches Prietos, PO = Potato Harbor, CH = China Harbor, PB = Pelican Bay, PL = Platt's Harbor, CE = Cave Entrance, and FE = Fern Cave. The ten major sites are grouped together from the westernmost site, to the southern, eastern and then northern. The two minor sites are grouped on the left of the table. Distribution (D) over the entire California range is designated after each species: W = widely distributed, N = predominately found in northern California, S = predominately found in southern California.

DIVISION CHLOROPHYTA (Green Algae)

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Bryopsis corticulans	W	2				1	1			1			
Bryopsis hypnoides	W					2							
Chaetomorpha linum	W		2	2	3	3	2		1				
Cladophora sp.	-								2		1		
Cladophora albida	W						2			1	1		
Cladophora columbiana	W		2	3	2	3	3	2		2	1		
Cladophora graminea	W	2			1					2			3
Codium fragile	W	3	1	2		1	2	3		4	2		
Codium setchellii	W				2								
Derbesia marina	W							1		1	1		
Enteromorpha sp.	-			2	2	2	2	2	2	3	2		
Ulva californica	S		3	3	3		1		2				
Ulva lobata	W	3	2	2	2	3		3		2	2		
Ulva taeniata	N		2	2		2							

DIVISION PHAEOPHYTA (Brown Algae)

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Colpomenia sp.	-		3	3			4	2	3	3	2		
Cystoseira osmundacea	W		2	3					2	1			
Desmarestia ligulata	W	2	1		1						1		
Dictyopteris undulata	S								2				
Dictyota binghamiae	W	1	2										
Dictyota flabellata	S					2			3		2		
Ectocarpus parvus	W	2		1		1		2		3	2		
Egregia menziesii	W		3	2	3	1	2	3	3	4	4		
Eisenia arborea	W	3	1	3			4	3		3	3		
Endarachne binghamiae	S			2									

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Halidrys dioica	S	2	3			3	3	3		3	3		
Hesperophycus harveyanus	W		3	3						1			
Hincksia granulosa	W		1							2			
Laminaria farlowii	W		1		2								
Laminaria setchellii	N	3											
Leathesia difformis	W		2			1		2	3	1			
Macrocystis pyrifera	W	3	2	1	2	1	2	3		3			
Pachydictyon coriaceum	W			2		2	2	2	2	2	3		
Pelvetia fastigiata	W		4	2		1	2			4			
Petalonia fascia	W			2	1	2			2				
Sargassum muticum	W						3	2	4	2	1		
Scytosiphon dotyi	W		1		2	2			1	2			
Scytosiphon lomentaria	W	1	1	2	1	1	2		1	3			
Sphacelaria didichotoma	W						1						
Taonia lennebackerae	S		1	1			2				1		
Zonaria farlowii	S						2						

DIVISION RHODOPHYTA (Red Algae)

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Acrochaetium sp.	-	1					1						
Acrosorium uncinatum	S								3				
Ahnfeltia plicata	W				1								
Amphiroa zonata	S									2			
Amplisiphonia pacifica	W			1									
Anisocladella pacifica	W		1	1									
Antithamnion defectum	W		1							2	1		
Asterocolax gardneri	W			1									
Bangia fusco-purpurea	W								1				
Bossiella sp.	-	3	3	1									
Bossiella californica	W	2						2					
Bossiella orbigniana	W	2	3	3	3	2	3	4	2	4	4		3
Calliarthron tuberculosum	W	2	2	2	1			3		3	3		
Callithamnion pikeanum	N	2	2										
Callithamnion rupicolum	S				1			1	3	1	2		
Callophyllis sp.	-	3		1									

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Callophyllis violacea	W	2			2					2			2
Centroceras clavulatum	S		2	2	2		2		2				
Ceramium sp.	-	1	1	1	1	1	2			1			
Ceramium californicum	W				1								
Ceramium caudatum	S							1		1			
Ceramium codicola	W			2				2		3	2		
Ceramium eatonianum	W		1		2	3	1	1		1	2		
Chondria californica	S						2		1	2			
Corallina sp.	-	2											2
Corallina officinalis	W		3	2			3	2	2	1	2		2
Corallina vancouveriensis	W	3	4	3	4	2	2	4	4	4	4		
Cryptopleura sp.	-	2	2	1	2	2	2	2	3	3	2		2
Cryptopleura lobulifera	W			1	3		1						
Cryptopleura violacea	W		2		3				2				
Cumagloia andersonii	W		2		1	1	3	2		1			
Endocladia muricata	W	3	3	3	3	4	3	3	2	3	4		
Erythrocystis saccata	W					1	2	2		2	2		
Erythrotrichia sp.	-	2		1							1		
Farlowia conferta	N								1				
Fauchea laciniata	W												1
Gastroclonium coulteri	W		2	2	2	2	2		1				1
Gelidium coulteri	W	3	1	1	3	3	3	3	3	3	3		
Gelidium nudifrons	S								1				
Gelidium purpurascens	W		2	1		2		2		3			
Gelidium pusillum	WD		1	2									
Gelidium robustum	W	1	1	1	1	1	1	3	4	2	2		
Gigartina canaliculata	W		4	2	4	2	4	3	3	4	4		
Gigartina exasperata	W		1		2		2			2	2		3
Gigartina harveyana	W		3	1	1				2				
Gigartina leptorhynchos	S		3	2	3	3	3		1				
Gigartina spinosa	S	2	3	2	4	1	3	3	3	3	3		1
Gigartina volans	W			2	2	1							
Gracilaria pacifica	W				3								
Gracilaria papenfussii	S		1	1		1							

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Gracilariophila oryzoides	W			1									
Grateloupia doryphora	W	1	2		3	2	2			2			
Gymnogongrus sp.	-				2	1		2					
Gymnogongrus leptophyllus	W		1	1	3								
Gymnogongrus platyphyllus	W				1				1				
Gymnothamnion elegans	S									2			
Haliptylon gracile	S						2						2
Halymenia californica	W	2									3		
Herposiphonia plumula	W	2					2			1			
Herposphonia verticillata	W	2	1	3			1	2	4	3			3
Heterosiphonia erecta	S								1	1			1
Hypnea valentiae	S								3				
Iridaea cordata	W	3	1	1	2						2		
Iridaea flaccida	W									2			
Iridaea heterocarpa	N				2	2							
Iridaea lineare	N	2											
Janczewskia gardneri	W								1				
Laurencia sp.	-		2						2				
Laurencia lajolla	N			2			3	3		2	2		
Laurencia pacifica	W		1	1		2		3	2	4	3		
Laurencia spectabilis	W		1	1			2	2	2	2	1		
Laurencia splendens	W		1				1		2				
Leptocladia binghamiae	S	1	1	1									1
Lithothrix aspergillum	W		4	2			4				1		
Mastocarpus papillatus	N	2	3	3	3	2	1	3		3	3		
Melobesia mediocris	W		2				2		3	3	2		
Microcladia coulteri	W	2	1	1	3	2		1	1				2
Nemalion helminthoides	W	2	2	1	1	2	3	3	1	3	3		
Neoptilota hypnoides	N	2											
Nienburgia andersoniana	W		1										
Odonthalia floccosa	N	2	1										
Platythamnion recurvatum	N		1										
Pleonosporium vancouverianum	W		1	1									
Plocamium cartilagineum	W		3		3		1			1		3	3

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Plocamium violaceum	W	3	2	1	1	1	2	1		3		2	1
Pogonophorella californica	W			1									
Polysiphonia sp.	-			1		1		1		1	1		
Polysiphonia acuminata	W			1		2			1				
Polysiphonia brodiaei	N								1				
Polysiphonia hendryi	W	1			2	3	1	1		1			
Polysiphonia pacifica	W				2	3							
Polysiphonia paniculata	W		1			3							
Polysiphonia savatieri	W						1						
Polysiphonia scopulorum	W		1							2			
Polysiphonia simplex	S		1	1									
Porphyra perforata	W	2	3	3	3	4	1	1	1	2			
Prionitis lanceolata	W	2	3	2	3	3	2	3	2	3	3		2
Prionitis lyalli	W				2		1						
Pterochondria woodii	S									2			
Pterocladia capillacea	S			1			3		4	1			
Pterosiphonia baileyi	W		1	1	2		1			2			
Pterosiphonia dendroidea	W	1	1	1			2	1	1	1	2		
Ptilothamnionopsis lejolisea	W							1					
Rhodoglossum affine	W	2	2	2	2	3	3	3	1	3	3		
Rhodymenia californica	W		2		2		2	1		3		3	1
Rhodymenia pacifica	W				2					1			
Sarcodiotheca gaudichaudii	W		1	1	1		1	2		2			
Schimmelmannia plumosa	N	1			1		1						
Schizymenia pacifica	W	2					1	2					
Scinaia confusa	W								1				
Smithora naiadum	W		2	2	3		4			3	2		
Sorella delicatula	W									2			
Tiffaniella synderiae	W		1	1	1					3			

DIVISION ANGIOSPERMAE (Flowering Plants)

SPECIES	D	WP	FC	UT	SA	LA	CP	PO	CH	PB	PL	CE	FE
Phyllospadix scouleri	W		3	2			4	3	3	3	3		
Phyllospadix torreyi	W		3		3				3				

Table 3. Species Not Recorded Previously In Published Records Of Santa Cruz Island Marine Macrophytes. Key: WD = widely distributed, N = northern species, S = southern species, * = species previously described only from Monterey, California, R = rare, O = occasional, C = common. See Appendix for complete checklist of reported macrophytes.

Species	Distribution	# Sites Where Found	Abundance Where Found
Ahnfeltia plicata	W	1	R
Amplisiphonia pacifica	W	1	R
Anisocladella pacifica	W	2	R
Asterocolax gardneri	W	1	R
Callithamnion pikeanum	N	2	O
Centroceras clavulatum	S	5	O
Ceramium caudatum	S	2	R
Cladophora albida	W	3	O
Codium setchellii	W	1	O
Derbesia marina	W	3	R
Farlowia conferta	N	1	R
Gigartina exasperata	W	6	O
Gigartina volans	W	3	O
Gracilaria pacifica	W	1	C
Gracilaria papenfussii	S	3	R
Gracilariophila oryzoides	W	1	R
Gymnothamnion elegans	S	1	O
Hincksia granulosa	W	2	O
Hypnea valentiae	S	1	C
Iridaea heterocarpa	N	1	O
Janczewskia gardneri	W	1	R
Laminaria setchellii	W	1	C
Odonthalia floccosa	N	3	O
Phyllospadix torreyi	W	3	C
Platythamnion recurvatum	N	1	R
Pogonophorella californica	W	1	R
Polysiphonia brodiaei	N	1	R
Polysiphonia scopulorum	W	3	C
Prionitis lyallii	W	2	O
Ptilothamnionopsis lejolisea	W	1	R
Schimmelmannia plumosa	W	3	R
Scinaia confusa	W	1	R
Sphacelaria didichotoma	W	1	O
Ulva taeniata	N	3	O

Table 4. Species Richness At Sites Surveyed During This Study.

Site Name	Location on Island	Number of Taxa
Pelican Bay	North Shore	83
Forney's Cove	West End	81
Univ. Trailer	Southwest Side	76
Coches Prietos	South Shore	72
Sauces	West Side	64
China Harbor	North Shore	62
Potato Harbor	North Shore	57
Platt's Harbor	North Shore	54
Laguna	South Shore	52
West Point	Northwest Point	43
Fern Cave	North Shore	18
Cave Entrance	North Shore	4

Table 5. Number of Species Occurring At Only One Site Or Multiple Sites.

Number of Sites Where Found	Number of Taxa	% of Total sp.
1	33	22.9
2	22	15.3
3	19	13.2
4	12	8.3
5	15	10.4
6	8	5.6
7	11	7.6
8	8	5.6
9	7	4.9
all 10 major sites	9	6.3

species richness. The sites with greatest richness (Pelican Bay, Forney's Cove, and University Trailer) were, in general, protected coastlines with relatively large intertidal areas. With the exception of West Point, all study sites had at least a few rocky areas or tidepools with some sand coverage. Although most sites did not appear to be strongly influenced by sand and had few sand-associated species, three psammophytes (Codium setchellii, Ahnfeltia plicata, and Gracilaria pacifica) were unique to Sauces.

On an island-wide basis, approximately 25% of the species were common in distribution (frequency). We rated a commonly distributed species as one that occurred at six or more of our 10 major sites. The majority, or about 50%, were found at three or fewer sites (Table 5). Of the new island records (Table 3), over 50% occurred rarely, usually at only one or a few sites, and may have been overlooked in previous collecting expeditions. Hypnea valientae, a new record for the island, was abundant when present, and may have expanded its range northward during the 1983-84 El Niño conditions when seawater temperatures in this area were above average.

Overall, only nine taxa were found at all ten major sites. These include: Cryptopleura sp., Endocladia muricata, Gelidium coulteri, G. robustum, Gigartina canaliculata, G. spinosa, Nemalion helminthoides, Prionitis lanceolata, and Rhodoglossum affine. All of these species are distributed widely along the western coast of the United States, and were reported previously from Santa Cruz Island.

NUMERICAL ANALYSIS OF SITES

The TWINSPAN analysis separated two cave sites (Fern Cave and Cave Entrance) from the remaining sites on the basis of low species richness. They were closest in this analysis to the West Point site (Fig. 6), which also had a low species richness and contained several shallow, cave-like areas. Thus, it is not surprising that West Point is grouped with the cave sites. For simplicity, Fern Cave and the Cave Entrance will be excluded from discussion of the remaining sites.

For our ten major sites, the DECORANA analyses gave identical results for the frequency classification scheme and for presence/absence (p/a) data (Fig. 7). Although the sites had between 43-83 species, many of the species were either rare or occasional within a site. The species that tended to be common within a site also were often geographically common. Thus, abundance patterns within sites were not unique enough to change the relationships among sites. The analyses show that most of the sites lie fairly close to one another on the principal components axes, whereas only a few sites (West Point, Laguna, and China Harbor) lie outside the main cluster (Fig. 7). These same sites also were separate in the first division in the TWINSPAN analysis (Fig. 6).

A strong geographic pattern in the data was not shown; however, three west end sites (University Trailer, Forney's Cove, and Sauces) did appear to be similar. They also were similar, however, to China Harbor, a north coast site (Figs. 6 and 7). Three of the north coast sites (Potato Harbor, Platt's Harbor, and Pelican Bay) were similar to each other, but showed similarity to Coches Prietos, a south coast site (Fig. 7). Although the number of sites representing each rock type was low, there was no obvious relationship between rock type and species richness or composition. This also was true for abalone abundance.

The most distinct site, using all analyses, was West Point. This site lies on the northwestern tip of the island, is very exposed to ocean swells, and may receive colder currents (Neushul et al. 1969, Hendricks 1977). The flora is characterized by having the lowest species richness

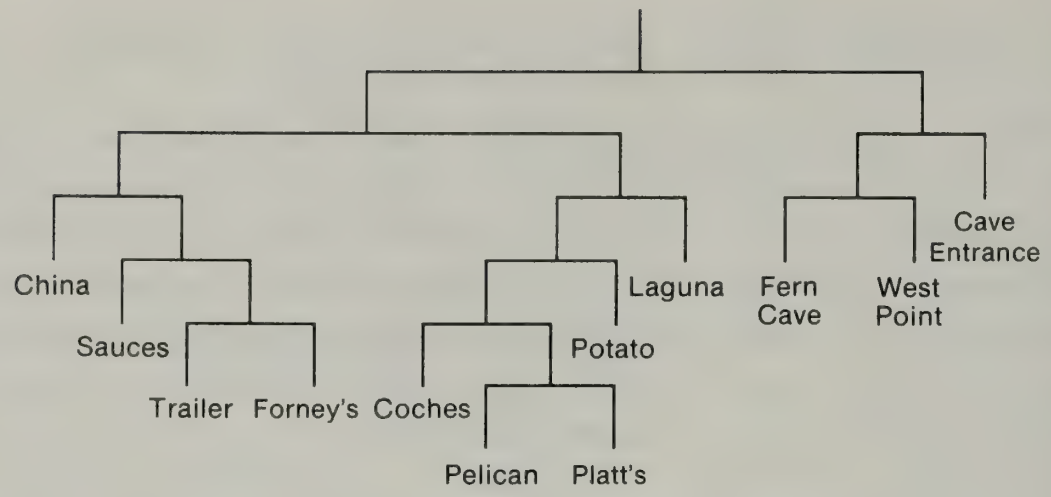

Figure 6. Dendrogram from TWINSPAN analysis based on intertidal marine macrophytes from all sites surveyed during this study of Santa Cruz Island.

of all of the major sites. Many geographically common species were missing from the site and three species were unique to the site. These species, Laminaria setchellii, Neoptilota hypnoides, and Iridaea lineare, were common and are more typical of northern water. Two other northern species, Callithamnion pikeanum and Odonthalia floccosa, were found only at West Point and its neighboring site, Forney's Cove, again suggesting strong northern affinities for this site.

Laguna was another site that showed strong differences from the other sites in both analyses. This south-facing area also was exposed to wave action and was found to be difficult to reach even on days when other sites were calm. The site had low species richness (Table 4), with the flora dominated by filamentous red algae, such as Polysiphonia spp. and Ceramium spp. Larger foliose algae were uncommon with the exception of Rhodoglossum affine and Grateloupia doryphora. Laguna contained few unique species. We conclude that local conditions, rather than geographic location, make this site unique.

China Harbor also was an outlier in the DECORANA analysis (Fig. 7). This site consisted of a large north-facing bay with extensive boulder fields and discontinuous small reefs. It had a large number of species found at no other sites (Table 5). Of these species, the majority were

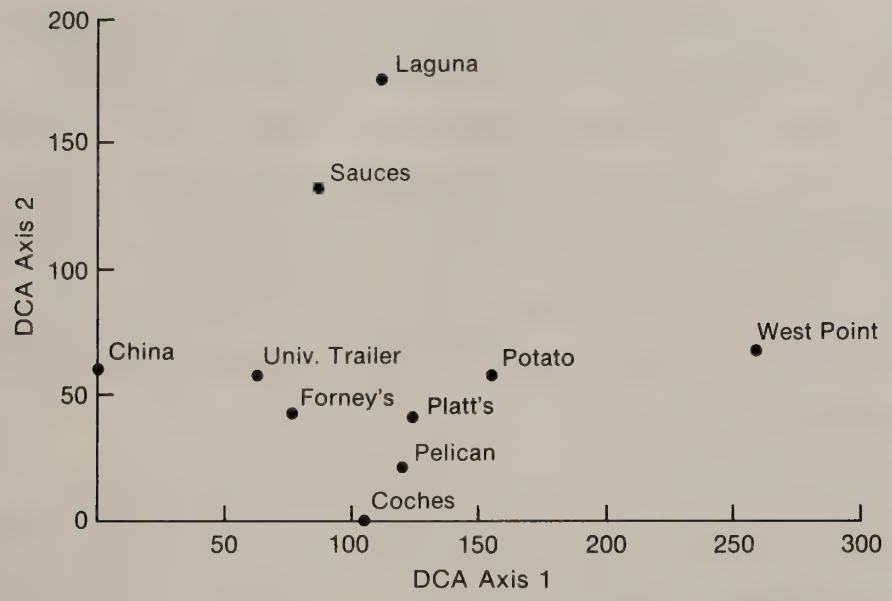

Figure 7. DECORANA ordination analysis by principal coordinates of the marine macrophytes for ten main sites (i.e., caves were excluded) on Santa Cruz Island. This analysis was obtained using both presence/absence data and scaled abundance estimates. The eigen value for the first coordinate was .310 in both cases.

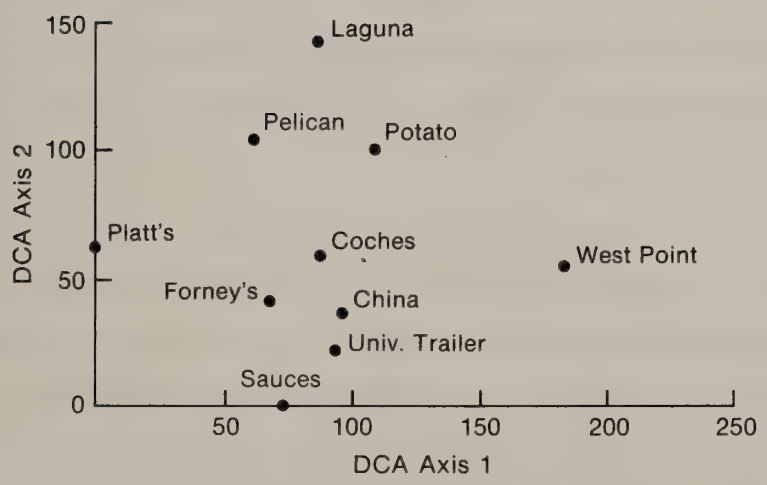

Figure 8. DECORANA ordination analysis by principal coordinates of the marine macrophytes of ten main sites surveyed in this study of Santa Cruz Island. This analysis was conducted on species lists where the species that were geographically rare (i.e., they occurred at few of the sites) were down-weighted in importance. Eigen value for the first axis was .189.

southern, including Hypnea valentiae, Acrosorium uncinatum, and Dictyopteris undulata. Each of these was common here. Dictyota flabellata, another southern species, was most common at this site. Three species (Farlowia conferta, Gelidium nudifrons, and Scinaia confusa) were included in the analysis, but were found only in the drift. This may have inadvertently skewed the analysis. However, China Harbor lacked a few common species and may be unique, because its orientation results in an influence from both southern and northern water (Seapy and Littler 1980).

In a revision of the DECORANA analysis, we downweighted geographically rare species (Fig. 8). As a result, China Harbor was no longer an outlier, suggesting that its uniqueness in the first analysis (Fig. 7) is due to its high number of unique species relative to the other sites (Table 6). West Point and Laguna, however, still were situated outside of the main cluster of points (Fig. 8). Sauces, a site that also tended to lie outside the main cluster in the original analyses (Fig. 7), was also less of an outlier when rare species were downweighted. This site contained three species unique to it and several other geographically uncommon species. The unique species are associated with sand-swept benches (Abbott & Hollenberg 1976), suggesting that the site's position in the analysis with respect to other sites was due in part to influence by sand.

Overall, Santa Cruz Island appears to be a transitional area between a northern and a southern marine flora. Seventy-three percent of all macrophyte species reported from the island are distributed widely along the California coast. Nine percent are 'northern' species and 18% are 'southern' species (Table 2). This suggests that Santa Cruz Island has more southern affinities than northern ones. Murray et al. (1980) reported similar findings in their analysis of species composition for intertidal macrophytes from Willows Anchorage on Santa Cruz Island. They found that this site was more similar to a site on Santa Barbara Island, one of the southern Channel Islands, than to sites where they collected on any of the northern islands. Although our survey included sites

Table 6. Number Of Unique Species Occurring At Each Site. Key: WD = widely distributed along California coast. S = has northern range limit in Southern California Bight. N = has southern range limit in Southern California Bight area.

Site	Unique Species	General Distribution
China Harbor	8	4=WD, 3=S, 1=N
Pelican Bay	4	3=S, 1=N
West Point	3	3=N
Sauces	3	3=WD
Univ. Trailer	3	3=WD
Coches Prietos	3	2=WD, 1=S
Forney's Cove	2	1=Monterey Only, 1=WD
Laguna	1	1=WD
Platt's Harbor	0	
Potato Harbor	0	

throughout the island, including some with more northern affinities, our data still suggest the island as a whole has more species in common with sites to the south of the Point Conception area. It would be interesting to resurvey these sites at several times in the future to determine whether this pattern persists. Of the 33 total occurrences of northern species, 72% were from the sites on the western portion of the island (West Point, Forney's Cove, University Trailer, Sauces, and Laguna). Southern species, however, were well distributed throughout the island, and 44% of their total occurrences were from the same west end sites. Thus, the entire island shows southern affinities, whereas it is primarily the western portion of the island that shows northern affinities. These west end sites correspond to the areas having generally colder water temperatures (Hendricks 1977). Thus, the occurrence of a greater number of northern species in those areas may reflect physiological tolerances of northern species or current patterns that tend to bring in both colder water and spores of northern species.

SUMMARY AND CONCLUSIONS

We surveyed ten main sites on the northern, western, and southern coastlines of Santa Cruz Island for the presence of non-crustose marine macrophytes. Each site varied in levels of wave action, intertidal area, substrate type, and presence of abalone. Species richness varied from 43 to 83 species. The sites protected from direct ocean swells had the highest species richness and overall abundances. Conversely, sites exposed to strong wave action (Laguna, West Point, Platt's Harbor), were lowest in species richness and overall abundance. Substrate type did not have any obvious effect on the type or amount of algal material present; however, this apparent lack of correlation with substrate may be the result of the small number of sites sampled relative to the number of rock types present.

Approximately 25% of the total number of species identified appear to be new records for Santa Cruz Island. The large percent of new records is probably the result of the increased number of sites sampled relative to past sampling efforts. The total number of marine intertidal macrophytes now recorded for Santa Cruz Island is 170 (Appendix I).

The classification techniques used to analyze the species assemblage relationships among sites did not produce any clear cause/effect patterns. Further studies including a greater number of sites may be instructive. Sites on the northern side of the island did tend to cluster together as did those at the west end, although some sites deviated from this general pattern. A large percent of the total number of species recorded were found at three or fewer sites. Because we sampled only ten sites intensively, it is difficult to detect patterns using these types of analyses. Overall, the intertidal flora contained representatives of both northern and southern coastal species. This is not surprising, because the island is situated in the region of the Southern California Bight. This region has long been recognized as transitional between northern and southern floras and faunas (Seapy & Littler 1978, Murray et al. 1980). What is perhaps surprising is that southern species are more strongly represented than northern ones.

Northern species were most strongly associated with sites from the western portion of the island, supporting oceanographic data that show colder temperatures in that area.

RECOMMENDATIONS

Although this survey documents the characteristic algal communities at several sites on Santa Cruz Island, no attempt was made to establish permanent transects at any of the sites. Such transects would be useful in providing quantitative evidence for long term persistence or change in these assemblages. Resampling of these sites at different seasons or in different years (even using the same methods we used) also would be instructive to monitor the types of fluctuations in species composition that might occur in these habitats. Resampling of our sites and those surveyed by Littler would be particularly valuable in the event of major disturbances, including oil spills that could produce significant alterations of habitats and species assemblages.

Biogeographic patterns are difficult to detect in communities such as those on Santa Cruz Island, where species richness is generally high, but where many species are locally and geographically rare. A more thorough understanding of factors controlling the regional distribution of algal species in the vicinity of Santa Cruz Island would involve sampling a greater number of sites throughout the island, particularly on the eastern portion, and a more detailed multivariate analysis. These analyses might help to identify groups of species more strongly associated with certain environmental conditions, including water temperate, rock type, or exposure. Experimental work, such as transplanting, could then be conducted to test hypothesis generated by the multivariate analyses. A more detailed study of ocean current patterns around the island also might help to clarify seemingly unusual distribution patterns.

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APPENDICIES

View northeastward
from vicinity of Fraser Point,
Santa Cruz Island

APPENDIX I

Annotated Catalogue of the Intertidal Macrophytes of Santa Cruz Island

This Annotated Catalogue includes all marine algae and flowering plants collected on Santa Cruz Island during our study. A checklist of all algae reported from intertidal and subtidal habitats at Santa Cruz Island is presented in Appendix III. All specimens cited in Appendix I are deposited in the UCSB Herbarium, with selected duplicate specimens deposited at the Santa Cruz Island Reserve Herbarium (SCIR) and the University Herbarium (UC) at the University of California, Berkeley. The catalogue is arranged in an order traditionally used for marine algae: the Chlorophyta are first, followed by the Phaeophyta and Rhodophyta algae, with the flowering plants last. Genera are arranged alphabetically within each group.

Included for each species are the scientific name, a brief description of relevant information regarding growth habit and intertidal location, abundance/distribution [abundance refers to the average relative percent cover for each taxon at each site: rare = less than four specimens seen at a site, occasional = between four and 20 specimens found, common = did not occupy more than 25% cover, abundant = occupied more than 25% cover within its respective intertidal zone; distribution (frequency) is the number of sites on the island where the taxa was found: rare = 1, occasional = 2-4, common = 5-7, abundant = 8-12]; and finally the specific site and field collection number for each specimen. The two letter site code is as follows: CE = Cave near Potato Harbor, CH = China Harbor, CP = Coches Prietos, FC = Forney's Cove, FE = Fern Cave, LA = Laguna, PB = Pelican Bay, PL = Platt's Harbor, PO = Potato Harbor, SA = Sauces, UT = University Trailer, WP = West Point. Collection number is our research team field number for voucher specimens. Figure numbers refer to photographs of algae in Appendix II.

ANNOTATED CATALOGUE

DIVISION CHLOROPHYTA (Green Algae)

Bryopsis corticulans Setch. Attached to substrate in mixed turf, low-mid intertidal; rare-occasional/occasional; WP 2500 2541, LA 2588, CP 2029, PB 2276.

Bryopsis hypnoides Lamour. Attached to substrate in mixed turf, mid-intertidal; occasional/rare; LA 2191.

Chaetomorpha linum (Müll.) Kütz. Attached to substrate in mixed turf, mid-high intertidal; rare-common/common; FC 1812, UT 1927, SA 2114, LA 2174, CP 2035, CH 2389.

Cladophora sp. Unidentifiable to species, rare/rare: PL 2435.

Cladophora albida (Huds.) KUtz. Attached to substrate, mid-high intertidal; rare-occasional/occasional; CP 2058 2059, PB 2272, PL 2447.

Cladophora columbiana Coll. Attached to substrate, mid-intertidal; rare-common/abundant; NW 1814 1869 1884, FC 1922, SA 2090, LA 2175, CP 2037, PO 2334, CH 2387, PB 2273 2280, PL 2449.

Cladophora graminea Coll. Attached to substrate, mid-intertidal or in pools; rare-common/occasional; WP 2506 2551 2557, SA 2112, PB 2262, FE, 2455.

Codium fragile (Sur.) Har. Attached to substrate, low-mid intertidal or in pools; rare-abundant/abundant; WP 2495 2528, FC 1816, UT 1888, LA 2576, CP 2010, PO 2338, PB 2229, PL 2402.

Codium setchellii Gardn. Attached to substrate, mid-intertidal; occasional/rare; SA 2093.

Derbesia marina (Lyngb.) Sol. Epizoic on sponge (2238), "Halicystis" stage attached to crustose coraline algae (2312, 2414), low intertidal; rare/occasional; PO 2312, PB 2238, PL 2414.

Enteromorpha sp. Unidentifiable to species, epiphytic or attached to substrate, all tidal levels; rare-common/abundant; UT 2473, SA 2151, LA 2165 2192, CP 1799 2067, PO 2355, CH 2386, PB 2250, PL 2448.

Ulva californica Wille. Attached to substrate, mid-high intertidal; rare-common/common; FC 1873, UT 1941, SA 2126, CP 2050, CH 1800.

Ulva lobata (KUtz.) S. & G. Attached to substrate or epiphytic, low-mid intertidal or in pools; occasional-common/abundant; WP 2556, FC 1875, UT 1942 2474, SA 2128, LA 2162 2164 2169, PO 2317 2354, PB 2300, PL 2443 2450.

Ulva taeniata (Setch.) S. & G. Attached to substrate or epizoic on mussels, low-mid intertidal or in pools; rare-common/occasional; FC 1874, UT 1942, LA 2162 2169.

DIVISION PHAEOPHYTA (Brown Algae)

Colpomenia sinuosa (Roth) Derb. & Sol. All Colpomenia spp. were placed into C. sinuosa, because it was not possible, due to morphological overlap, to distinguish C. peregrina. Attached to substrate, low-high intertidal; occasional-abundant/common; FC 1825, UT 1921, CP 2012 2016 2070, PO 2307, CH 1780, PB 2245, PL 2413.

Cystoseira osmundacea (Turn.) C. Ag. Attached to substrate, low intertidal or in deep pools; rare-common/occasional; FC 1807, UT 1885, CH 1765, PB 2243.

Desmarestia ligulata (Lightf.) Lamour. Attached to substrate, low intertidal; rare-occasional/occasional; WP 2523, FC 2490, SA 2080, PL 2397.

Dictyopteris undulata Holmes. Attached to substrate, low intertidal; occasional/rare; CH 1762.

Dictyota binghamiae J. Ag. Attached to substrate, low intertidal; rare-occasional/occasional; WP 2517, FC 1819.

Dictyota flabellata (Coll.) S. & G. Attached to substrate, low-mid intertidal; occasional-common/occasional; LA 2579, CH 2375, PL 2437.

Ectocarpus parvus (Saund.) Hollenb. Fig. 15. Epiphytic on various brown algae, primarily on old portions of Eisenia and Halidrys; rare-occasional/common; WP 2494 2497 2568, UT 1912 2484, LA 2577, PO 2313 2342, PL 2429.

Egregia menziesii (Turn.) Aresch. Attached to substrate, low intertidal and in pools; rare-abundant/abundant; FC 1822, UT 1944, SA 2076, LA 2160, CP 2004, PO 2340, CH 1785, PB 2237, PL 2409.

Eisenia arborea Aresch. Attached to substrate, very low intertidal, heavy surge areas; rare-abundant/common; WP 2492 2543, FC 1834, UT 1940, CP 2002, PO 2340 2345, PB 2249, PL 2408 2409.

Endarachne binghamiae J. Ag. Attached to substrate in sandy area, mid-intertidal, occasional/rare; UT 2472.

Halidrys dioica Gardn. Attached to substrate, low intertidal; common/common; WP 2535, FC 2488, LA 2178, CP 2003, PO 2343, PB 2218, PL 2410.

Hesperophycus harveyanus (Decne.) S. & G. Attached to substrate, mid-high intertidal; rare-common/occasional; FC 1828, UT 1891, PB 2215.

Hincksia granulosa (J. E. Smith) Silva. Fig. 17. Attached to substrate, in mixed turf, mid intertidal or in pools; rare-occasional/occasional; FC 1852, PB 2241 2246.

Laminaria farlowii Setch. Attached to substrate, very low intertidal; rare-occasional/occasional; FC 1815, SA 2085.

Laminaria setchellii Silva. Attached to substrate, very low intertidal; common/rare; WP 2493 2531.

Leathesia difformis (L.) Aresch. Attached to substrate, low-mid intertidal; rare-common/occasional; FC 2478, LA 2583, PO 2316, CH 2372, PB 2247, PL 2415.

Macrocystis pyrifera (L.) C. Ag. Attached to substrate, very low intertidal or in deep pools, rare-common/abundant; WP 2522, FC 1806, UT 1943, SA 2105, LA 2187. CP 2005, PO 2346, PB 2239.

Pachydictyon coriaceum (Holmes) Okam. Attached to substrate or sometimes epiphytic on Cystoseira, low-mid intertidal or in pools; occasional-common/common; UT 1909, CP 2034 LA 2179, PO 2341, CH 1765 1778, PB 2259, PL 2400.

Pelvetia fastigiata (J. Ag.) DeToni. Attached to substrate, mid-high intertidal; rare-common/common; FC 1804, UT 1892, LA 2188, CP 2006, PB 2223.

Petalonia fascia (Müll.) Kuntze. Attached to substrate, mid-intertidal; rare-occasional/occasional; UT 1934, SA 2137, LA 2177, CH 1795.

Sargassum muticum (Yendo) Fensh. Attached to substrate, low-mid intertidal in protected areas; rare-abundant/common; CP 2046, CH 1787, PO 2315, PB 2227, PL 2441.

Scytosiphon dotyi Wynne. Attached to substrate, mid-high intertidal; rare-occasional/occasional; FC 2482, SA 2121, LA 2163 2208, CH 1779, PB 2270.

Scytosiphon lomentaria (Lyngb.) J. Ag. Attached to substrate, low-mid intertidal; rare-common/common; WP 2547, FC 1823, UT 1926, SA 2149, LA 2176, CH 1782, CP 2018 2019, PB 2269.

Sphacelaria didichotoma Saund. Fig. 27. Epiphytic on Sargassum; rare/rare; CP 2073.

Taonia lennebackerae J. Ag. Attached to substrate, low-mid intertidal; rare-occasional/occasional; FC 1810, UT 1911, CP 2051, PL 2430.

Zonaria farlowii S. & G. Attached to substrate, low intertidal; occasional/rare; CP 2040.

DIVISION RHODOPHYTA (Red Algae)

Acrochaetium sp. Epiphytic on Sargassum muticum; rare/occasional; WP 2568, CP 2073.

Acrosorium uncinatum (Turn.) Kyl. Epiphytic on Pterocladia sp. and other species; common/rare; CH 1768.

Ahnfeltia plicata (Huds.) Fries. Attached to substrate, low intertidal; rare/rare; SA 2100.

Amphiroa zonata Yendo. Attached to substrate, low intertidal; occasional/rare; PB 2266.

Amplisiphonia pacifica Hollenb. Epiphytic on holdfast of Eisenia, low intertidal; rare/rare; UT 1916.

Anisocladella pacifica Kyl. Attached to sandy substrate, beneath Phyllospadix beds, low intertidal or in pools; rare/occasional; FC 1844, UT 1896.

Antithamnion defectum Kyl. Fig. 9. Epiphytic on coralline algae or epizoic on mussels, high to low intertidal; rare/occasional; UT 1885, PB 2231, PL 2441.

Asterocolax gardneri (Setch.) Feldm. & Feldm. Parasitic on Anisocladella; rare/rare; UT 1895.

Bangia fusco-purpurea (Dillw.) Lyngb. Attached to substrate, high intertidal-splash zone; rare/rare; CH 1776.

Bossiella sp. Unidentifiable to species; WP 2546, FC 1836, UT 1917.

Bossiella californica (Dec.) Silva. Attached to substrate, mid-low intertidal; occasional-common/occasional; WP 2512 2514 2560 2561, PO 2353.

Bossiella orbigniana (Dec.) Silva. Attached to substrate, low intertidal; occasional-abundant/abundant; WP 2513, FC 1837 1838, UT 1901, SA 2095 2109 2110, LA 2159, CP 2023, PO 2335, CH 1769, PB 2552 2304, PL 2431, FE 2466 2468.

Calliarthon tuberculosum (Post. & Rupr.) Dawson. Attached to substrate, low intertidal or in pools; rare-common/common; WP 2526, FC 1860 1861, UT 1920, SA 2091, PB 2242, PO 2350, PL 2424 2425.

Callithamnion pikeanum Harv. Attached to substrate, high intertidal; occasional/occasional; WP 2500 2501, FC 2481.

Callithamnion rupicolum Anders. Fig. 10. Epiphytic on other algae, typically Corallina spp. rare-occasional/common, SA 2139, PO 2311, CH 1783, PB 2253 2256, PL 2432 2435.

Callophyllis sp. Unidentifiable to species; WP 2575, UT 1953.

Callophyllis violacea J. Ag. Attached to substrate, low intertidal; occasional/occasional; SA 2118, PB 2301, CE 2369.

Centroceras clavulatum (C. Ag.) Mont. Fig. 11. Attached to substrate in mixed algal turf or epiphytic, low-mid intertidal; rare-common/common; FC 1858 1860 1862 1864, UT 1924, SA 2150, CP 2041 2056 2065, CH 1786.

Ceramium spp. Unidentifiable to species, due to lack of diagnostic reproductive structures; WP 2555 2562, FC 1879, UT 1955 2485, LA 2195 2578 2587 2591, CP 2068 2073, PB 2277.

Ceramium californicum J. Ag. Fig. 12. Epiphytic on Prionitis, low intertidal; occasional/rare; SA 2143.

Ceramium caudatum S. & G. Fig. 13. Attached to substrate in mixed delicate turf or epiphytic, low intertidal; rare/occasional; PO 2351, PB 2283.

Ceramium codicola J. Ag. Epiphytic on Codium fragile; occasional-common/occasional; WP 2529, UT 1890, PO 2339, PB 2203 2283, PL 2403.

Ceramium eatonianum (Farl.) DeToni. Fig. 14. Attached to substrate in mixed delicate turf or epiphytic on a variety of algae, mid-intertidal; rare-common/common; FC 1872, SA 2145, LA 2196 2199 2201 2206, CP 2065, PO 2347, PB 2257 2260 2278 2286, PL 2434 2435.

Chondria californica (Coll.) Kyl. Epiphytic on variety of algae, typically Sargassum muticum; rare-common/occasional; CP 2060, CH 1803, PB 2261 2295.

Corallina sp. Unidentifiable to species; WP 2560 2561, FE 2467.

Corallina officinalis var. chilensis (Dec.) Kütz. Attached to substrate, low-mid intertidal or in pools; rare-common/common; FC 1840, UT 1917, CP 2036, PO 2330, CH 1771, PB 2302, PL 2423, FE 2457.

Corallina vancouveriensis Yendo. Attached to substrate, low-mid intertidal or in pools; occasional-abundant/abundant; WP 2510 2553, FC 1839, UT 1839, SA 2083, LA 2166, PO 2337, CH 1772 1774, PB 2254, PL 2426.

Cryptopleura sp. Most of these specimens are probably C. corallinara, but lack critical reproductive stages for confirmation; epiphytic on a variety of algae particularly Corallina; rare-common/abundant; WP 2539, FC 1853, UT 1950, SA 2133 2134, LA 2584, CP 2052 2054, PO 2349 2364, PB 2291, PL 2444, FE 2462.

Cryptopleura lobulifera (J. Ag.) Kyl. Attached to substrate or epiphytic, low intertidal; rare-common/occasional; UT 1930, SA 2138, CP 2036.

Cryptopleura violacea (J. Ag.) Kyl. Attached to substrate or more commonly epiphytic, low-mid intertidal; occasional-common/occasional; FC 1826, SA 2131, CH 2382.

Cumagloia andersonii (Farl.) S. & G. Attached to substrate, mid-high intertidal; rare-common/common; FC 2479, SA 2084, LA 2161, CP 2050, PO 2331, PB 2258.

Endocladia muricata (Post. & Rupr.) J. Ag. Attached to substrate, mid-high intertidal; occasional-abundant/abundant; WP 2540, FC 1843, UT 1938, SA 2102, LA 2171, CP 2074, PO 2329, CH 1803, PB 2279, PL 2445.

Erythrocystis saccata (J. Ag.) Silva. Epiphytic on Laurencia pacificum, except (2420) which was epiphytic on L. spectabilis, mid-intertidal; rare-occasional/occasional; LA 2590, CP 2038, PO 2320, PB 2274, PL 2420 2442.

Erythrotrichia sp. Fig. 16. Epiphytic on various kelps, mixed with Ectocarpus parvus; rare/occasional; WP 2497 2568, UT 1912 2484.

Farlowia conferta (Setch.) Abb. Drift, washed up on shore; rare/rare; CH 2377.

Fauchea laciniata J. Ag. Attached to substrate, low intertidal pool; rare/rare; FE 2459.

Gastroclonium subarticulatum (Turner) Kütz. Attached to substrate, frequently in mixed turf, low-mid intertidal or in pools; rare-occasional/common; FC 1859, UT 1923, SA 2082, LA 2158, CP 2027, CH 1781, FE 2453.

Gelidium coulteri Harv. Attached to substrate, sometimes epiphytic, low-high intertidal, primarily mid-intertidal, or in pools; rare-abundant/abundant; WP 2527, FC 1880, UT 1945, SA 2088, LA 2172 2173 2213, CP 2031, PO 2358 2359 2364, CH 1798, PB 2285 2287, PL 2438 2440.

Gelidium nudifrons Gardn. Drift, washed up on shore; rare/rare; CH 2383.

Gelidium purpurascens Gardn. Attached to substrate, sometimes epiphytic, low intertidal or in pools; rare-common/common; FC 1846 1848, UT 1939, LA 2181, PO 2356, PB 2284.

Gelidium pusillum (Stackh.) Le Jol. Attached to substrate, in dense turf with Endocladia, mid-high intertidal; rare-occasional/occasional; FC 1882, UT 1938.

Gelidium robustum (Gardn.) Hollenb. & Abb. Attached to substrate, very low intertidal, sometimes in pools; rare-abundant/abundant; WP 2534, FC 1830, UT 1886, SA 2107, LA 2185, CP 2030, PO 2344, PB 2232, CH 1789, PL 2433.

Gigartina canaliculata Harv. Attached to substrate, low-mid intertidal or in pools; occasional-abundant/abundant; FC 1841, UT 1902, CP 2011, SA 2086, LA 2157, PO 2327, CH 1793, PB 2219 2293, PL 2422.

Gigartina exasperata Harv. & Bail. Attached to substrate, low intertidal; occasional-common/common; FC 2487, SA 2096 2120, CP 2007, PB 2217, PL 2396, FE 2363.

Gigartina harveyana (Kütz.) S. & G. Attached to substrate, low intertidal or in pools; rare-common/occasional; FC 1805, UT 1914, SA 2104, CH 2373.

Gigartina leptorhynchos J. Ag. Attached to substrate, low-mid intertidal or in pools; rare-common/common; FC 1835, UT 1925, SA 2081, LA 2153, CP 2013, CH 1770.

Gigartina spinosa (Kutz.) Harv. Attached to substrate, low intertidal or in pools; rare-common/abundant; WP 2525, FC 1809, UT 1913, SA 2099 2136, LA 2186, CP 2028, CH 1788, PO 2322, PB 2216, PL 2395, FE 2463.

Gigartina volans (C. Ag.) J. Ag. Attached to substrate, low intertidal; rare-common/occasional; UT 1935 1951, SA 2094 2111 2115, LA 2211.

Gracilaria pacifica Abb. Attached to substrate, in sandy areas, patchy distribution; common/rare; SA 2089.

Gracilaria papenfussii Abb. Attached to substrate, low-mid intertidal pools; rare/occasional; FC 1813 1851, UT 1957, LA 2580.

Gracilariophila oryzoides Setch. & Wils. Parasitic on Gracilaria papenfussii; rare/rare; UT 1958.

Grateloupia doryphora (Mont.) Howe. Attached to substrate, low-mid intertidal or in pools; rare-common/common; WP 2505 2544, FC 1854, SA 2123, LA 2182 2210, CP 2061, PB 2289 2290 2305.

Gymnogongrus sp. Unidentifiable to species; SA 2142, LA 2212, PO 2365.

Gymnogongrus leptophyllus J. Ag. Attached to substrate, low intertidal pools; rare/occasional; FC 1842, UT 1904 1947 1954, SA 2098.

Gymnogongrus platyphyllus Gardn. Attached to substrate, low intertidal; rare/occasional; SA 2135, CH 2392.

Gymnothamnion elegans (C. Ag.) J. Ag. Fig. 18. Attached to substrate in mixed delicate turf, mid-intertidal, isolated patch found on mussels in small cave; rare/rare; PB 2221 2226 2233.

Haliptylon gracile (Lamour.) Johans. Attached to substrate, low intertidal; occasional/occasional; CP 2044, FE 2467.

Halymenia californica Smith & Hollenb. Attached to substrate, in localized patches, low intertidal; occasional-common/occasional; WP 2532, PL 2399.

Herposiphonia plumula (J. Ag.) Hollenb. Epiphytic on Corallina spp.; rare-occasional/occasional; WP 2501 2558, CP 2064, PB 2277.

Herposiphonia verticillata (Harv.) Kyl. Epiphytic on other algae, particularly Corallina spp.; rare-abundant/abundant; WP 2259 2563 2564, FC 1872, UT 1908, CP 2068, PO 2332, CH 1784, PB 2288, PL 2436, FE 2461.

Heterosiphonia erecta Gardn. Attached to substrate or epiphytic, low intertidal; rare/occasional; CH 1802, PB 2255, FE 2452.

Hypnea valentiae (Turn.) Mont. Attached to substrate in turf or epiphytic on other algae, low intertidal; common/rare; CH 1766 2376 2378.

Iridaea cordata (Turn.) Bory. Attached to substrate, low-mid intertidal; rare-common/ occasional; WP 2524, FC 1847, UT 1936, SA 2108 2113 2216, PL 2398.

Iridaea flaccida (S. & G.) Silva. Attached to substrate, low intertidal; occasional/rare; PB 2299.

Iridaea heterocarpa Post. & Rupr. Attached to substrate, low intertidal; occasional/occasional; SA 2120 2146 2147, LA 2180.

Iridaea lineare (S. & G.) Kyl. Attached to substrate, low intertidal in areas of heavy surge; occasional/rare; WP 2496.

Janczewskia gardneri Setch. & Guerns. Parasitic on Laurencia spectabilis; rare/rare; CH 2393.

Laurencia sp. Unidentifiable to species; FC 1863 1871, CH 1796 1797.

Laurencia lajolla Daws. Attached to substrate in dense turf, low-mid intertidal; occasional-common/common; UT 1937, CP 2043, PO 2324, PB 2271, PL 2412.

Laurencia pacifica Kyl. Attached to substrate forming turf, low-mid intertidal; rare-abundant/common; FC 1820 1867 1868, UT 1948, LA 2170, PO 2319, CH 1794 2371, PB 2225, PL 2416.

Laurencia spectabilis Post. & Rupr. Attached to substrate, low intertidal or in pools; rare-occasional/common; FC 1865, UT 1889, CP 2021, PO 2318, CH 1763, PB 2292, PL 2421.

Laurencia splendens Hollenb. Attached to substrate in turf or epiphytic, low-mid intertidal; rare-occasional/occasional; FC 1871, CP 2022, CH 2374.

Leptocladia binghamiae J. Ag. Attached to substrate, low intertidal or in pools; rare/ occasional; WP 2566, FC 1817, UT 1903, FE 2454.

Lithothrix aspergillum Gray. Attached to substrate, low intertidal or in pools; rare-abundant/occasional; FC 1821, UT 1898, CP 2024, PL 2419.

Mastocarpus papillatus (C. Ag.) Kützt. Attached to substrate, mid-high intertidal, sometimes in pools; rare-abundant/abundant; WP 2511 2537, FC 1824, UT 1928 1929, SA 2101 2117 2140, LA 2156, CP 2045, PO 2326, PB 2298, PL 2417.

Melobesia mediocris (Fosl.) Setch. & Mason. Epiphytic on Phyllospadix, low intertidal; occasional-common/common; FC 1831, CP 2000, CH 1761, PB 2264, PL 2406.

Microcladia coulteri Harv. Epiphytic on other algae, typically Prionitis or Gigartina; rare-common/abundant; WP 2508 2572, FC 1881, UT 1915, SA 2122, LA 2183, PO 2333, CH 1767 1790, FE 2465.

Nemalion helminthoides (Vell.) Batt. Attached to substrate, high intertidal; rare-common/abundant; WP 2533, FC 2480, UT 1887, CP 2025, SA 2106, LA 2167 2209, PO 2323, CH 1775, PB 2222, PL 2407.

Neoptilota hypnoides (Harv.) Kyl. Attached to substrate, mid-intertidal; occasional/rare; WP 2548.

Nienburgia andersoniana (J. Ag.) Kyl. Attached to substrate, mid-intertidal pool; rare/rare; FC 1866.

Odonthalia floccosa (Esp.) Falk. Attached to substrate, low intertidal; rare-occasional/occasional; WP 2545, FC 2486, CP 2017.

Platythamnion recurvatum Woll. Fig. 19. Epizooic on sponge, high intertidal pool; rare/rare; FC 1857.

Pleonosporium vancouverianum (J. Ag.) J. Ag. Fig. 20. Epiphytic on coraline algae; rare/occasional; FC 1876, UT 1907.

Plocamium cartilagineum (L.) Dix. Attached to substrate, low-mid intertidal or in pools; rare-common/common; FC 1811, SA 2079, CP 2008, PB 2267, FE 2456, CE 2367.

Plocamium violaceum Farl. Attached to substrate, on steep rock faces, low intertidal; rare-common/abundant; WP 2552, UT 1897, SA 2127, LA 2184 2204, CP 2009, PO 2336, PB 2268, FE 2460, CE 2368.

Pogonophorella californica (J. Ag.) Silva. Attached to substrate under Phyllospadix bed in loose sand, low intertidal; rare/rare; UT 1893.

Polysiphonia sp. Unidentifiable to species; UT 1952, LA 2192 2197, PO 2317 2321, PB 2250, PL 2404.

Polysiphonia acuminata Gardn. Epiphytic on other algae, typically Gigartina spp.; rare/occasional; UT 1900 2470 2483, LA 2581, CH 1801 2390.

Polysiphonia brodiaei (Dillw.) Spreng. Epiphytic on Prionitis, rare/rare, CH 2394.

Polysiphonia hendryi Gardn. Fig. 21. Attached to substrate in delicate turf or epiphytic on a variety of algae or epizooic, mid-intertidal; rare-common/ common; WP 2549, SA 2144, LA 2194 2198 2203 2577 2587 2589, CP 2062, PO 2310, PB 2246 2286.

Polysiphonia pacifica Hollenb. Fig. 22. Attached to substrate in delicate turf, mid-intertidal; rare-common/occasional; PO 2309 2347, PB 2226.

Polysiphonia paniculata Mont. Fig. 23. Attached to substrate in delicate turf or sometimes epiphytic; rare-common/ occasional; FC 1877 1878, LA 2190 2200 2205 2210 2586 2587.

Polysiphonia savatieri Har. Epiphytic on Sargassum; rare/rare; CP 2069.

Polysiphonia scopulorum var. villum (J. Ag.) Hollenb. Fig. 24. Attached to substrate in delicate turf, mid-intertidal; rare-common/occasional; FC 1883, UT 2476, PB 2220 2240 2246 2251.

Polysiphonia simplex Hollenb. Attached to substrate in sandy pools or epiphytic; rare/occasional; FC 1877, UT 1900.

Porphyra perforata J. Ag. Attached to substrate, sometimes epiphytic, high intertidal; rare-abundant/abundant; NW 2518 2530, FC 1818, UT 1910, SA 2097, LA 2152, CP 2039, PO 2352, CH 1777, PB 2228.

Prionitis lanceolata (Harv.) Harv. Attached to substrate, low-mid intertidal or in pools; occasional-common/abundant; WP 2502 2569 2570, FC 1808, UT 1932, SA 2103, LA 2155, CP 2026, PO 2308, CH 1767 1790, PB 2235, PL 2401, FE 2458.

Prionitis lyallii Harv. Attached to substrate, low intertidal; rare-occasional/occasional; SA 2129 2143, CP 2032.

Pterochondria woodii (Harv.) Hollenb. Fig. 25. Epiphytic on a variety of algae; occasional/rare; PB 2281.

Pterocladia capillacea (Gmel.) Born. & Thur. Attached to substrate, sometimes epiphytic, low intertidal or in pools; rare-abundant/occasional; UT 1946, CP 2033, CH 1791, PB 2282.

Pterosiphonia baileyi (Harv.) Falk. Attached to substrate or epiphytic on a variety of algae, low-mid intertidal or in pools; rare-occasional/common; FC 1870, UT 1956, SA 2148, CP 2073, PB 2236.

Pterosiphonia dendroidea (Mont.) Falk. Fig. 26. Attached to substrate, epiphytic on a variety of algae or epizoic, low-mid intertidal or in pools; rare-occasional/common; WP 2515, FC 1860, UT 1906, CP 2049, CH 1764 2388, PO 2342 2346, PB 2240, PL 2446.

Ptilothamnionopsis lejolisea (Farl.) Dix. Epiphytic on articulations of coralline algae; rare/rare; PO 2328.

Rhodoglossum affine (Harv.) Kyl. Attached to substrate, sometimes epiphytic, low-mid intertidal or in pools; rare-common/abundant; WP 2504 2538, FC 1833, UT 1931 1933 1949, SA 2125, LA 2154 2168 2214, CP 2020, PO 2348, CH 1764, PB 2248, PL 2418.

Rhodymenia californica Kyl. Attached to substrate, low-mid intertidal or in pools; rare-common/common; WP 2519, FC 1845, SA 2130, CP 2048, PO 2366, CH 2384, PB 2296, FE 2464, CE 2370.

Rhodymenia pacifica Kyl. Attached to substrate, low intertidal; rare-occasional/occasional; SA 2132, PB 2297.

Sarcodiotheca gaudichaudii (Mortagne) Gabrielson. Attached to substrate, low-mid intertidal or in pools; rare-occasional/common; FC 1849 1850, UT 1894, SA 2087, CP 2014, PO 2325, PB 2275.

Schimmelmannia plumosa (Setch.) Abb. Attached to substrate, low intertidal; rare/occasional; WP 2565, SA 2141, CP 2042.

Schizymenia pacifica (Kyl.) Kyl. Attached to substrate, low intertidal; rare-occasional/occasional; WP 2499 2536, CP 2015, PO 2360 2362.

Scinaia confusa (Setch.) Huisman. Drift, washed up on shore; rare/rare; CH 2379.

Smithora naiadum (Anders.) Hollenb. Epiphytic on Phyllospadix; occasional-abundant/common; FC 1832, UT 1919, SA 2078, CP 2001, PB 2265, PL 2406.

Sorella delicatula (Gardn.) Hollenb. Epizoic on mussels; occasional/rare; PB 2234.

Tiffaniella snyderiae (Farl.) Abb. Attached to substrate in delicate turf or under Phyllospadix, low intertidal or in pools; rare-common/occasional; FC 1864 1869, UT 1905, SA 2119, PB 2221 2226.

Unidentified Alga. Fig. 28. Unidentifiable to genus; WP 2550 2554 2567, FC 1856, UT 1959, SA 2092 2124, LA 2189 2193, CP 2047 2057 2071 2072 2075, PO 2357 2361, CH 1773 2381 2385 2391, PB 2224 2294 2303, PL 2427 2428 2439 2451.

DIVISION ANGIOSPERMAE (Flowering Plants)

Phyllospadix scouleri Hook. Attached to substrate, low intertidal or in pools; occasional-abundant/common; FC 1827, UT 1918, CP 2000, PO 2306, CH 1792, PB 2263, PL 2405.

Phyllospadix torreyi Wats. Attached to substrate, low intertidal or in pools; common/occasional; FC 1829, SA 2077, CH 1760.

APPENDIX II

SELECTED MARINE ALGAE FROM SANTA CRUZ ISLAND

Many of the algae collected during this study were small, filamentous species. Because algae of this type are difficult to collect or identify, they are frequently overlooked. Several hundred microsope slides of filamentous algae identified during this study are deposited in the UCSB Herbarium. We have selected 20 specimens for illustration to assist marine collectors with the proper identification of these small filamentous species. Descriptions that are provided in Marine Algae of California (Abbott and Hollenberg 1976), in conjunction with the photos and captions presented here, should help to identify these generally overlooked species.

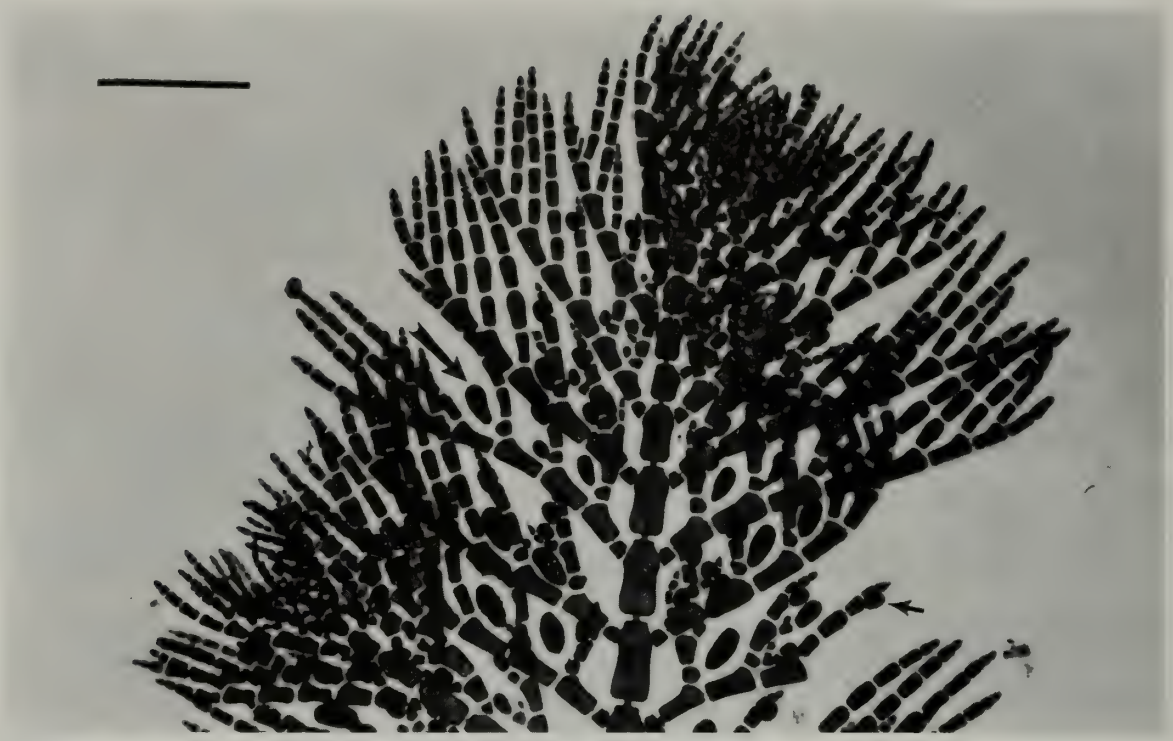

Fig. 9. *Antithamnion defectum* Kyl.

Fig. 10. *Callithamnion rupicolum* Anders.

Fig. 9. Antithamnion defectum Kyl. ERT 2411.

This red alga is characterized by opposite branching of the primary lateral branches and unilateral branching of the secondary lateral branches. Tetrasporangia (big arrow) are found in the axis of the secondary lateral branches. "Gland" cells (small arrow) are found on the end of the secondary lateral branches. It was an uncommon epiphyte or epizoic species on Santa Cruz Island. Scale bar = 150 μ.

Fig. 10. Callithamnion rupicolum Anders. ERT 2253.

This red alga is characterized by alternate branching of the primary branches. Considerable variation in the branching pattern occurs toward the bases. Tetrasporangia (arrow) are borne in a series on the branches. It was a common mid-intertidal alga on Santa Cruz Island, and forms delicate tufts of "fuzz". Scale bar = 500 μ.

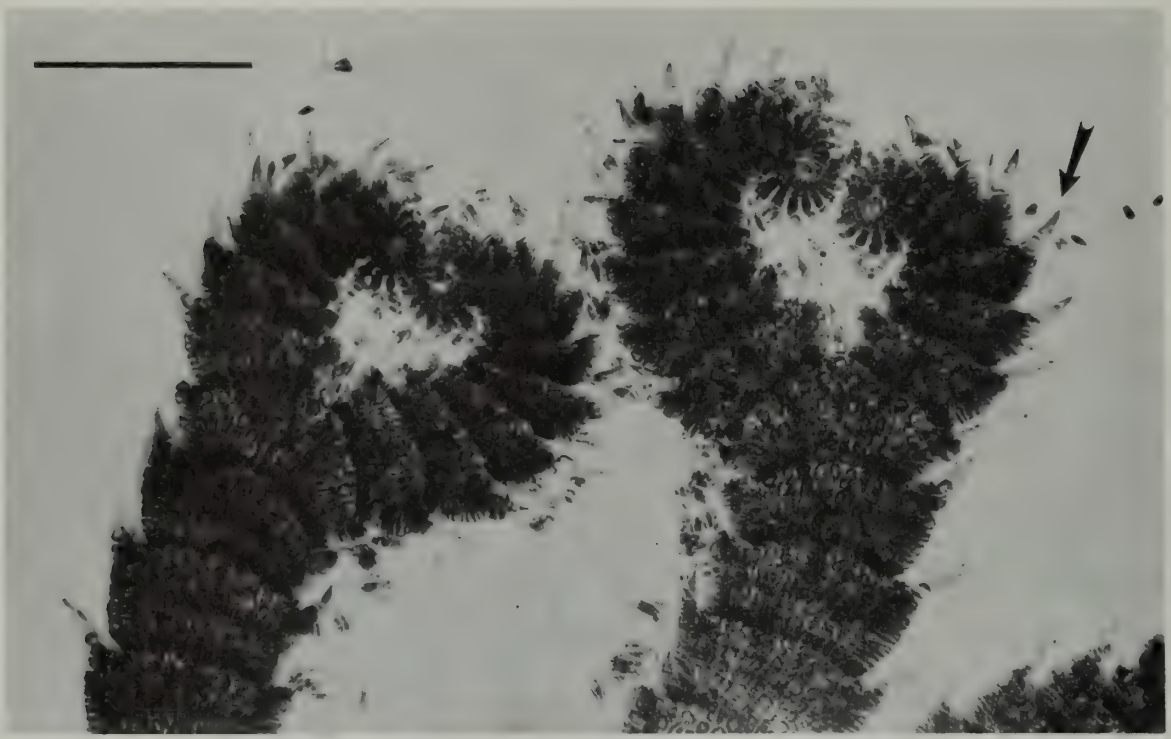

Fig. 11. *Centrocerus clavulatum* (C. Ag.) Mont.

Fig. 12. *Ceramium californicum* J. Ag.

Fig. 11. Centrocerus clavalatum (C. Ag.) Mont. ERT 2056.
This red alga is characterized by dichotomous branching, tips that are curved inward, a corticated surface and distinct spines (arrow) that project from the nodes. The presence of spines readily distinquishes this species from all members of the closely related genus Ceramium. This species was common on Santa Cruz Island and formed dense clumps of hair-like filaments to 10 centimeters long. Several species of Polysiphonia have identical growth habits and are easily confused with C. clavulatum. Scale bar = 500 μ.

Fig. 12. Ceramium californicum J. Ag. ERT 2143.
This red alga is characterized by dichotomous branching, slightly inwardly curved tips, and cortication that is predominately at the nodes; however, the cortication spreads very close to the next cortical band. Tetrasporangia (arrow) are found embedded in the upper portions of the cortical bands. This alga was rare on Santa Cruz Island. Scale bar = 500 μ.

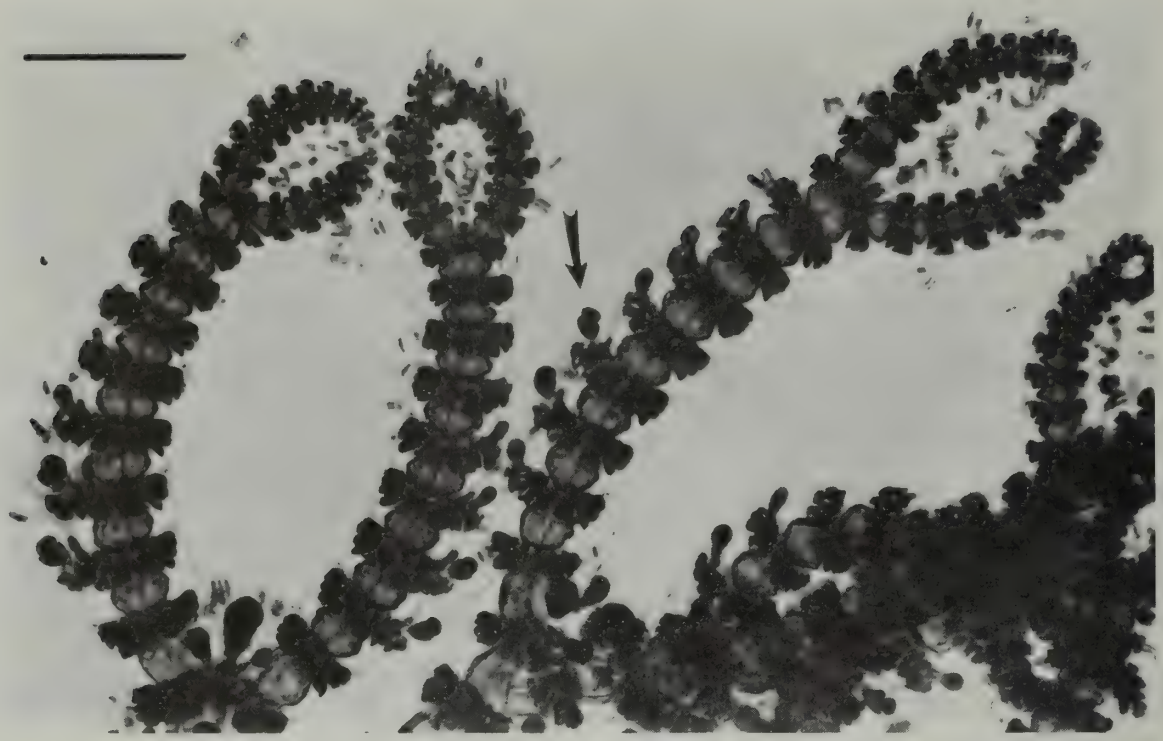

Fig. 13. *Ceramium caudatum* S. & G.

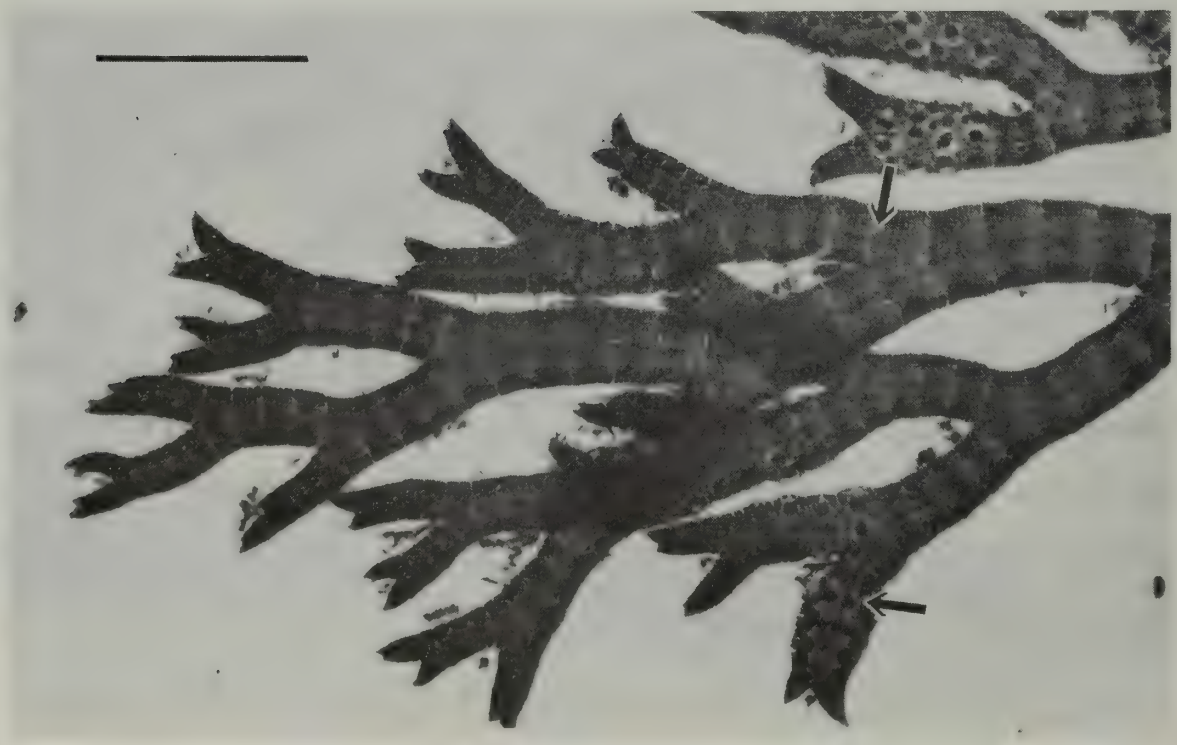

Fig. 14. *Ceramium eatonianum* (Farl.) Detoni

Fig. 13. Ceramium caudatum S. & G. ERT 2283.

This red alga has a delicate, dichotomously branched thallus with inwardly curved tips. It is distinquishable from other species of Ceramium by having cortication only at the nodes, with the lower cortical cells being considerably larger than the upper cortical cells. Tetrasporangia (arrow) project from the upper cortical cells. This alga was rare on Santa Cruz Island. Scale bar = 150 μ.

Fig. 14. Ceramium eatonianum (Farl.) DeToni ERT 2145.

This red alga has dichotomous branching, but unlike most other species of Ceramium the tips have a slight outward curvature and the thallus is completely corticated. The cortical cells are in distinct longitudinal rows and "gland" cells (small arrow) are present at the nodes. Tetrasporangia (big arrow) are embedded in the cortical tissue. This species was a common epiphyte on a variety of algae and the most common Ceramium species found on Santa Cruz Island. Scale bar = 500 μ.

Fig. 15. *Ectocarpus parvus* (Saund.) Hollenb.

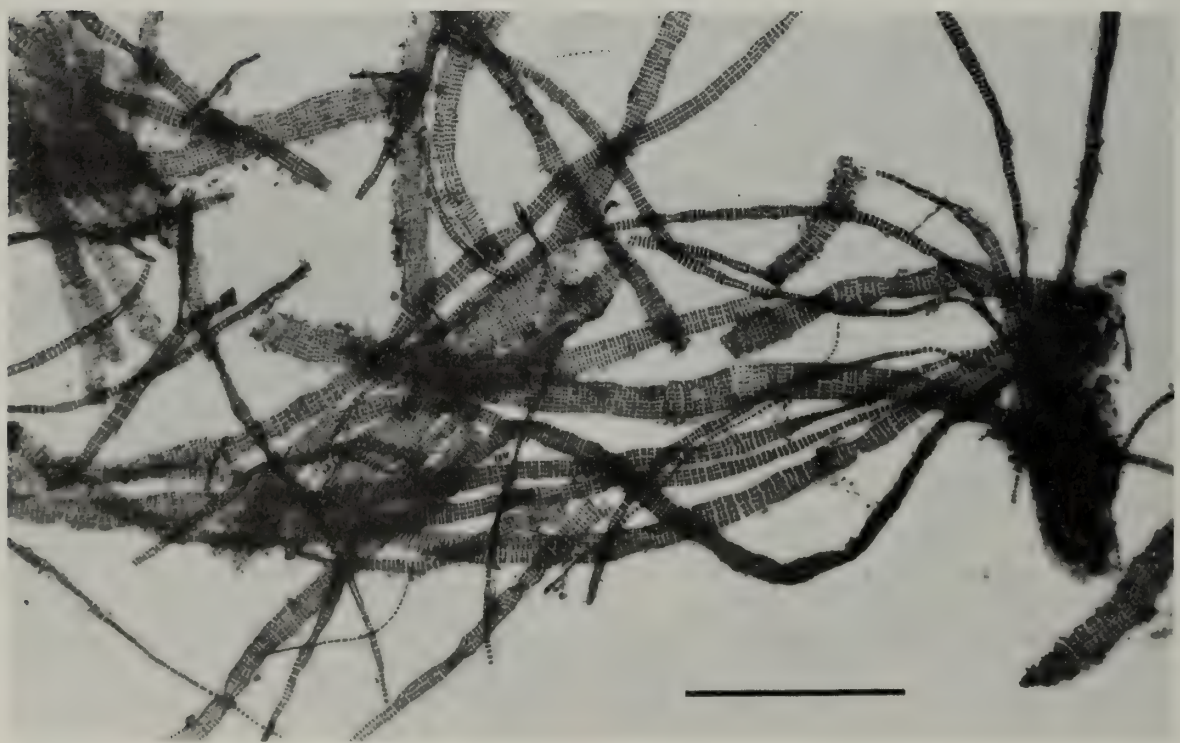

Fig. 16. *Erythrotrichia* sp.

Fig. 15. Ectocarpus parvus (Saund.) Hollenb. ERT 2484.
This brown alga was a very common epiphyte that formed dense, 1 cm long tufts on older blades of various kelps, including Eisenia, Laminaria, Halidrys, and Cystoseira. The filaments are uniseriate, sparsely branched, and bear numerous, corn-cob shaped, plurilocular sporangia (arrow). Scale bar = 150 μ.

Fig. 16. Erythrotrichia sp. ERT 1912.
This red alga is recognizable by a minute frond that is uniseriate near the base and monostromatic, but is 6-8 cells wide in the upper portions. It was found as an epiphyte on a variety of kelps and intermixed with the dense tuft of Ectocarpus parvus. Scale bar = 500 μ.

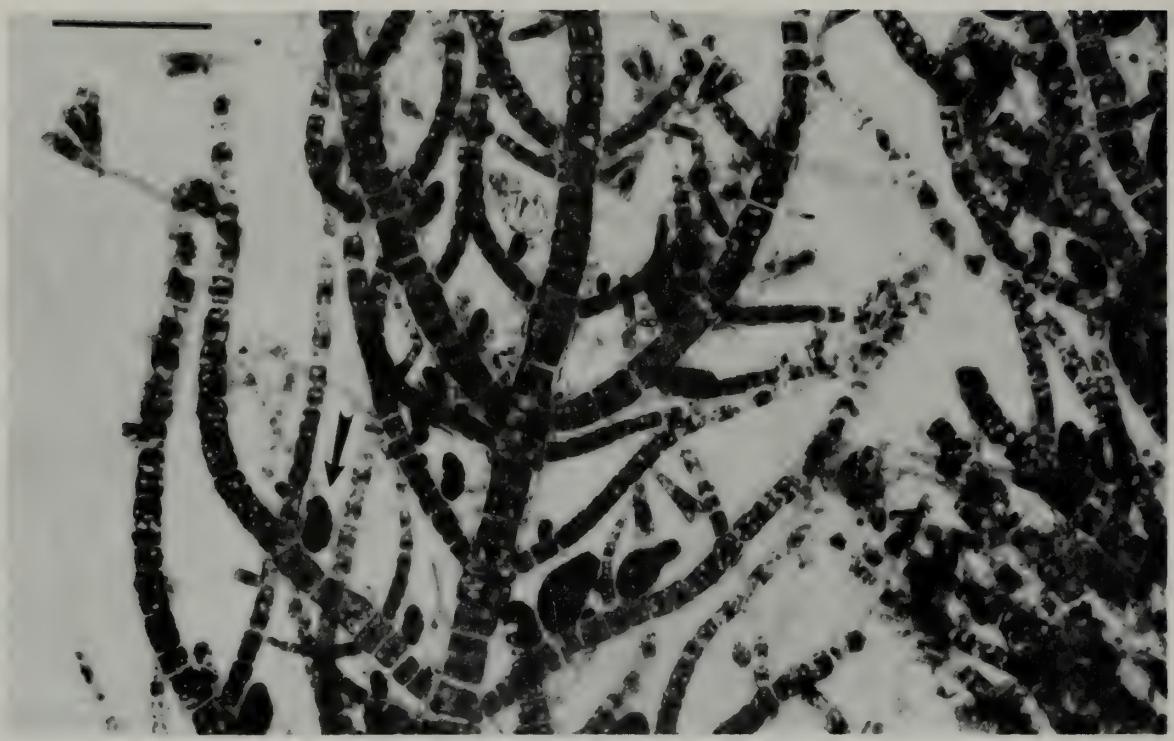

Fig. 17. *Hincksia granulosa* (J. Smith) Silva.

Fig. 18. *Gymnothamnion elegans* (C. Ag). J. Ag.

Fig. 17. Hincksia granulosa (J. Smith) Silva. [Giffordia granulosa (J. Smith) Ham.] ERT 1852.

This brown alga is characterized by sub-opposite branching and plurilocular sporangia (arrow). The sporangia are sessile, ovoid and have a slight curvature to one side. This alga was found occasionally in sheltered pools, forming fine hair-like clumps several centimeters long. Scale bar = 150 μ.

Fig. 18. Gymnothamnion elegans (C. Ag.) J. Ag. ERT 2233.

This red alga is a minute (5 mm), delicate, tufted thallus. Lateral branching is opposite along the main axis, with secondary laterals usually absent. The most characteristic feature is the presence of tetrasporangia (arrow) on the tips of the lateral branches. This alga was rare on Santa Cruz Island. Scale bar = 150 μ.

Fig. 19. *Platythamnion recurvatum* Woll.

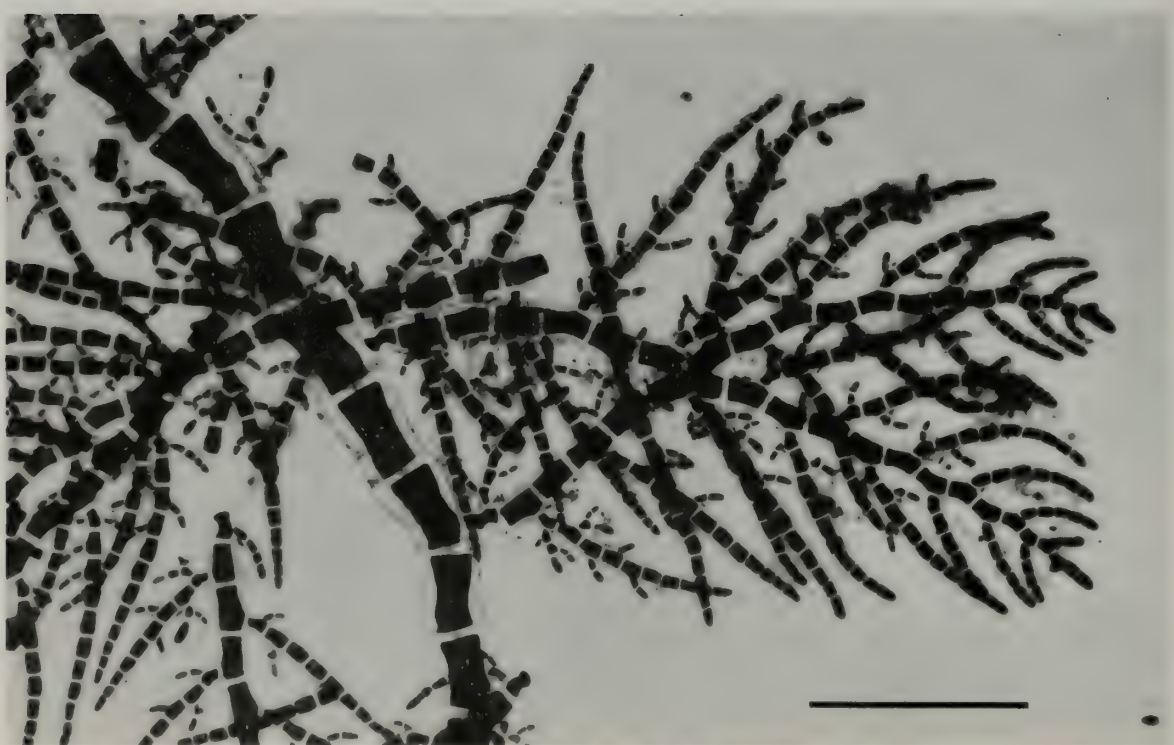

Fig. 20 *Pleonosporium vancouverianum* (J. Ag.) J. Ag.

Fig. 19. Platythamnion recurvatum Woll. ERT 1857.
This red alga has distinctly whorled branches with four lateral branches at each whorl. Secondary branching is unilateral and tetrasporangia (arrow) are borne on the secondary branches. This alga was rare on Santa Cruz Island. Scale bar = 150 μ.

Fig. 20. Pleonosporium vancouverianum (J.Ag.) J.Ag. ERT 1907.
This red alga is characterized by alternate branching on the primary and secondary laterals. The primary character for this genus is the presence of polysporangia instead of tetrasporangia. Species in the genus Callithamnion are very similiar and sometimes inseparable if no polysporangia are present. This alga was occasionally found as an epiphyte on coralline algae. Scale bar = 500 μ.

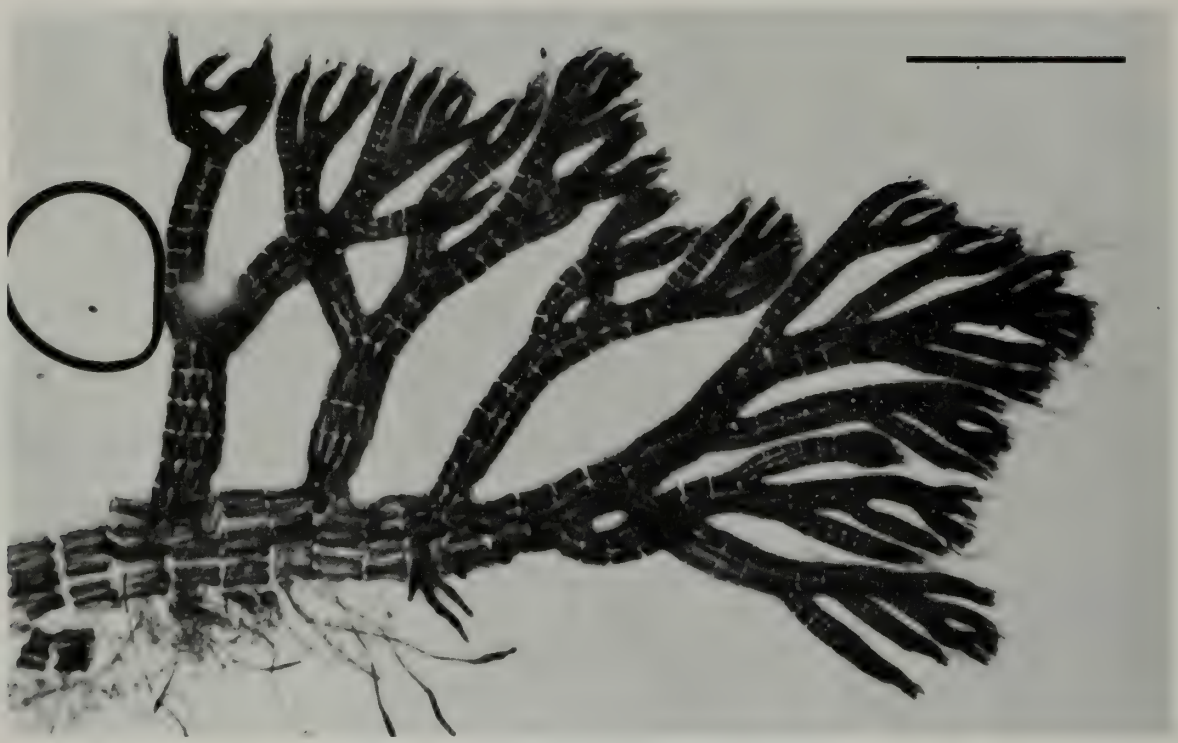

Fig. 21. *Polysiphonia hendryi* Gardn.

Fig. 22. *Polysiphonia pacifica* Hollenb.

Fig. 21. Polysiphonia hendryi Gardn. ERT 2144.

This red alga has polysiphonous construction consisting of 10-12 pericentral cells. Hairs are usually present only at the tip. This common species is highly variable, but it is fairly large in size and densely branched. This species is similar to P. pacifica, but is readily distinquished by the number of pericentral cells. Scale bar = 500 μ.

Fig. 22. Polysiphonia pacifica Hollenb. ERT 2309.

This red alga has polysiphonous construction with four pericentral cells. The thallus is usually densely branched in a fairly regular alternating pattern. Hairs are rarely present. This species is similar to P. hendryi, but is distinquished by the number of pericentral cells. Scale bar = 500 μ.

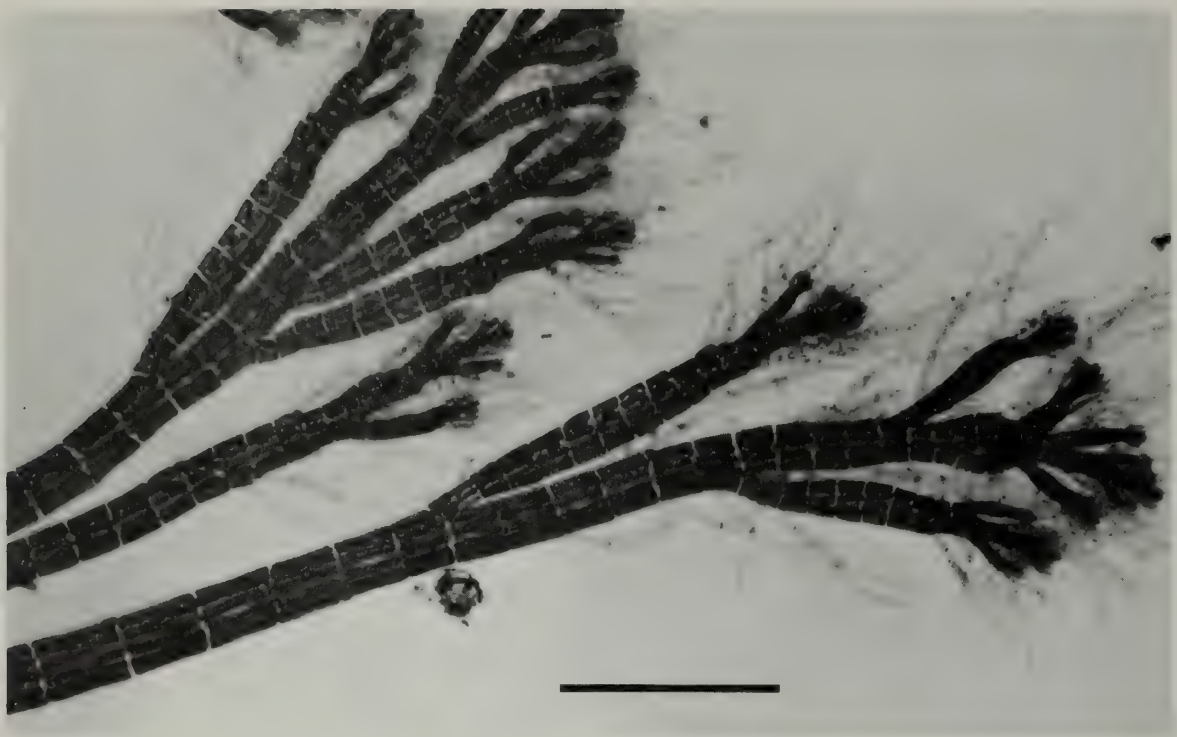

Fig. 23. *Polysiphonia paniculata* Mont.

Fig. 24. *Polysiphonia scopulorum* var. *villum* (J. Ag.) Hollenb.

Fig. 23. Polysiphonia paniculata Mont. ERT 2190.
This red alga also has polysiphonous construction with 10-12 pericental cells. The thallus is usually sparsely branched and has a limited prostrate axis. This species can be confused with P. scopulorum var. villum, which has a similar habit, but only four pericentral cells. Scale bar = 500 μ.

Fig. 24. Polysiphonia scopulorum var. villum (J.Ag.) Hollenb. ERT 2240.
This red alga has polysiphonous construction with four pericentral cells. The thallus has a distinct prostrate axis with a sparsely branched, erect axis. This specimen is producing spermatangial clusters (arrow). This species is very similar to P. paniculata, but is readily separated by the number of pericentral cells. Scale bar = 500 μ.

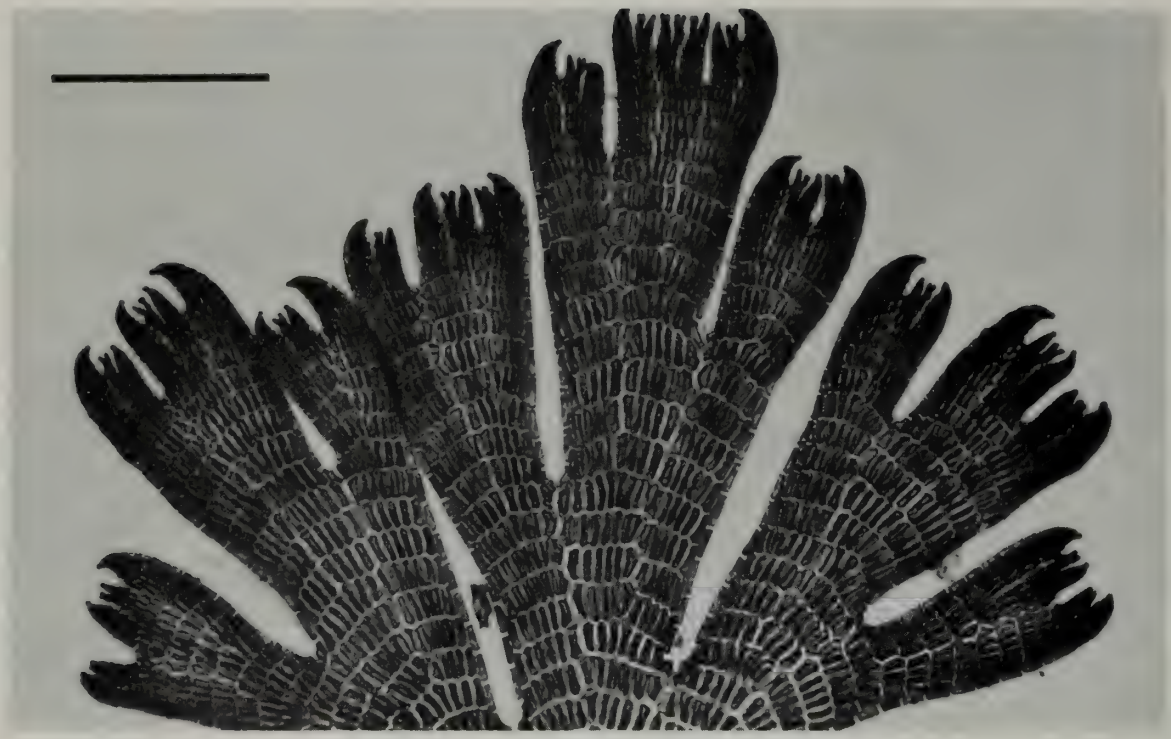

Fig. 25. *Pterochondria woodii* (Harv.) Hollenb.

Fig. 26. *Pterosiphonia dendroidea* (Mont.) Falk.

Fig. 25. Pterochondria woodii (Harv.) Hollenb. ERT 2281.
This distinctive red alga has a strongly flattened, ribbon-like thallus with 10-20 pericentral cells and an overall thallus size reaching several centimeters. The branching pattern is more or less alternate. This species was an occasional epiphyte on Cystoseira. Scale bar = 500 μ.

Fig. 26. Pterosiphonia dendroidea (Mont.) Falk. ERT 2446.
This common red alga has a polysiphonous-type construction with alternate distichous branching with an overall thallus size of several centimeters. The lateral branches have a slight inward curvature. This species was found typically as an epiphyte on a variety of algae, but was also saxicolous. Scale bar = 500 μ.

Fig. 27. *Sphacelaria didichotoma* Saund.

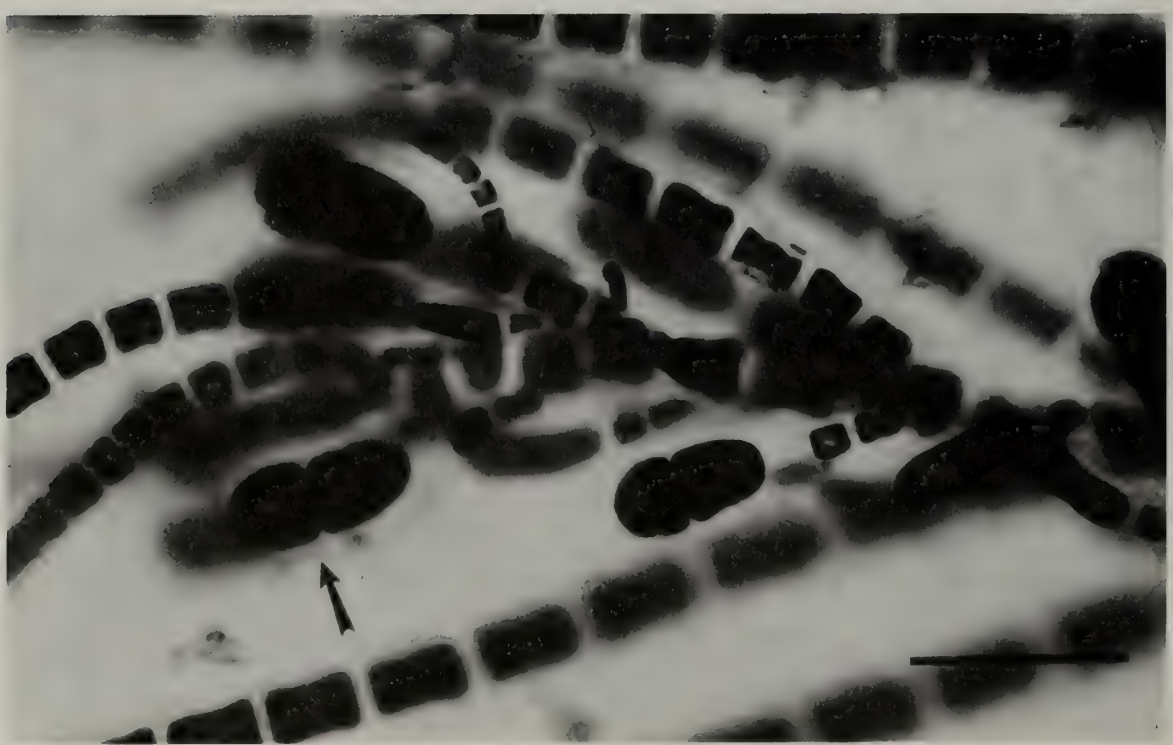

Fig. 28. Unidentified alga.

Fig. 27. Sphacelaria didichotoma Saund. ERT 2073.

This brown alga has a prominent apical cell and multiseriate axis that is superficially similar to the red algal genus Polysiphonia. This species is sparsely branched and bears vegetative propagules (arrow) that are slender and characteristically bifurcate. This alga was found as an epiphyte on Sargassum. Scale bar = 150 μ.

Fig. 28. Unidentified alga. ERT 2246.

This ceramiacious red alga has alternate branching with the cells of the lateral branches smaller than those of the main axis. Secondary laterals are rarely present. Near the apex, bisporangia (arrow) are produced on short determinate lateral branches. This rare alga was found attached to rocks in the mid-intertidal zone intermixed in dense algal turf. It was small (2-5 mm) and only a few specimens were found. It appears to be similar to Callithamniella, but is different from all known species because of the presence of bisporangia. Scale bar = 50 μ.

APPENDIX III

CHECKLIST OF MARINE MACROPHYTES REPORTED FROM SANTA CRUZ ISLAND

The following species list encompasses known published information regarding the marine macrophytes of Santa Cruz Island. A previous list completed by Murray (1974) surveyed the early literature, and is included herein. Many of the recent reports are from Littler (1978, 1979) and Apt et al. (1988). Included for each species are scientific name, general distribution (W = widespread, N = northern, S = southern), occurrence in the intertidal (I), subtidal (S) or both, and reference number(s) for the published record(s) that are listed at the end. Synonyms are listed in brackets. Question marks following a name indicate that some question was indicated by the reporting author regarding the identification. Figure numbers refer to photographs of algae in Appendix II. The arrangement is by division with the Chlorophyta (green algae) first, followed by Phaeophyta (brown algae), Rhodophyta (red algae), and Angiospermae (flowering plants). Genera are alphabetical within each division. A total of 280 taxa of marine macrophytes have been reported from Santa Cruz Island: 23 greens, 42 browns, 212 reds, and 3 angiosperms. Thirty-three taxa of the total were identified only to genus.

CHECKLIST OF MARINE MACROPHYTES

DIVISION CHLOROPHYTA (Green Algae)

Bryopsis corticulans Setch.	W	I,S	3,9,13,14, 15
Bryopsis hypnoides Lamour.	W	I	3,13
Chaetomorpha linum (Müll.)Kütz.	W	I	3,13,14
Chaetomorpha spiralis Okam.	S	I	13,14
Cladophora sp.	-	I,S	3,14,16
Cladophora albida (Huds.)Kütz.	W	I,	3
Cladophora columbiana Coll. [*C. trichotoma* S.& G.]	W	I,S	3,13,14
Cladophora graminea Coll.	W	I,S	3,9,10,15
Cladophora hutchinsiae (Dillwyn) Kütz. [?]	-	S	16
Codium cuneatum S.& G.	S	I	2,15,17
Codium fragile (Sur.)Har.	W	I,S	3,13,14,15 16,17
Codium hubbsii Daws.	S	I	13
Codium johnstonei Silva	S	S	2,15,16
Codium setchellii Gardn.	W	I	3
Derbesia marina (Lyngb.)Sol. [*Halocystis ovalis* (Lyngb.) Aresch.]	W	I	3
Enteromorpha sp.	-	I	3,14
Enteromorpha compressa (L.)Grev.	W	I	14
Enteromorpha flexuosa (Roth)J.Ag. [*E. tubulosa* Kütz.]	W	I	13
Prasiola meridionalis S.& G.	N	I	2,15,18
Ulva sp.	-	S	16
Ulva californica Wille	S	I	3,13,14

Ulva lobata (Kütz.) S.& G.	W	I,S	3,9,13,14
Ulva taeniata (Setch.) S.& G.	N	I	3

DIVISION PHEAOPHYTA (Brown Algae)

Acinetospora sp.	-	S	16
Agarum fimbriatum Harv.	N	S	15,16
Colpomenia peregrina (Sauv.)Ham.	N	S	10
Colpomenia sinuosa (Roth)Derb.& Sol.	S	I	3,13,14
Cylindrocarpus rugosus Okam. [Petrospongium rugosum (Okam.)S.& G.]	W	I	13,14
Cystoseira sp.	-	I	16
Cystoseira neglecta S.& G.	S	I	13
Cystoseira osmundacea (Turn.)C.Ag.	W	I,S	3,9,10,14
Desmarestia ligulata (Lightf.)Lamour. [D. herbacea (Turn.) Lamour.]	W	I,S	3,14,15,16
Dictyoneuropsis reticulata (Saund.)Smith	N	I	15,18
Dictyopteris johnstonei Gardn.	S	I	4,14,18
Dictyopteris undulata Holmes [D. zonarioides Farlow]	S	I,S	3,13,14,15 16
Dictyota binghamiae J.Ag.	W	I,S	3,15,16
Dictyota flabellata (Coll.)S.& G.	S	I	3,13,14
Ectocarpus sp.	-	I	13
Ectocarpus parvus (Saund.)Hollenb. [E. pygmaeus] Fig. 15.	W	I,S	3,16
Egregia menziesii (Turn.)Aresch.	W	I,S	3,9,13,14, 15,16,18
Eisenia arborea Aresch.	W	I,S	3,10,13,14 15,16
Endarachne binghamiae J.Ag.	S	I	3,13,14
Feldmannia cylindrica (Saund.)Holl.& Abb.	W	I	15,16

Halidrys dioica Gardn.	S	I,S	3,10,13,14 15,16
Hapterophycus canaliculatus S.& G.	S	I	13,14
Hesperophycus harveyanus (Decne.)S.& G.	W	I	3,14,15
Hincksia granulosa (J.E.Smith)Silva [*Giffordia granulosa* (J.E.Smith) Ham.] Fig. 17	W	I	3
Hincksia mitchellae (Harv.)Silva [*Giffordia mitchellae* (Harv.) Ham.]	S	S	10
Laminaria farlowii Setch.	W	I,S	3,9,10,14, 15,16
Laminaria setchellii Silva [*L. dentigera* Kjellm.]	N	I	3,18
Leathesia difformis (L.)Aresch.	W	I	3
Macrocystis pyrifera (L.)C.Ag.	W	I,S	3,9,10,13, 14,15,16
Pachydictyon coriaceum (Holmes)Okam.	W	I,S	3,9,13,15, 16
Pelagophycus porra (Lem.)Setch.	W	S	15,16
Pelvetia fastigiata (J.Ag.)DeToni	W	I	3,13,14
Petalonia fascia (Mull.)Küntz.	W	I	3,13,14
Pseudolithoderma nigra Hollenb.	S	I	4,13,14
Ralfsia sp.	-	I	13
Sargassum muticum (Yendo)Fensh.	W	I	3,14
Sargassum palmeri Grun.	S	S	15,16
Scytosiphon dotyi Wynne	W	I	3,13,14
Scytosiphon lomentaria (Lyngb.)J.Ag.	W	I	3,13,14
Sphacelaria didichotoma Saund. Fig. 27.	W	I	3
Taonia lennebackerae J.Ag.	S	S	3,9,15,16
Zonaria farlowii S.& G.	S	I,S	3,9,10,14

DIVISION RHODOPHYTA (Red Algae)

Acrochaetium sp.	-	I,S	3,16
Acrochaetium tenuissimum (Coll.)Papenf.	S		15
Acrochaetium thuretii (Born.)Coll.& Herv.	S		2
Acrosorium uncinatum (Turn.)Kyl.	S	I,S	3,10,14, 15,16
Ahnfeltia sp.	-	S	16
Ahnfeltia plicata (Huds.)Fries	W	I	3
Amplisiphonia pacifica Hollenb.	W	I	3
Amphiroa zonata Yendo	S	I	3,13,14
Anisocladella pacifica Kyl.	W	I	3
Antithamnion defectum Kyl. Fig. 9. [A. pygmaeum Gardn.]	W	I,S	3,15,16
Asterocolax gardneri (Setch.)Feldm.& Feldm.	W	I	3
Bangia fusco-purpurea (Dillw.) Lyngb.	W	I	3,14
Bonnemaisonia hamifera Harv.	S		2,5,15
Bossiella sp.	-	I	3
Bossiella californica (Dec.)Silva [B. pachyclada Taylor]	W	I	2,3,12,15
Bossiella chiloensis (Dec.)Johans. [Bossea sagittata Daws.& Silva] [Bossea insularis Daws.& Silva]	N	I	3,12,15
Bossiella orbigniana			
ssp. orbigniana (Dec.)Silva	W	S	9,10,16
ssp. dichotoma(Manza)Johans.		I	3,13,14
[Bossea cooperi Daws.& Silva]			
Botryocladia pseudodichotoma (Farl.)Kyl.	W	S	10,15,16
Calliarthron cheilosporioides Manza	W	S	9,10
Calliarthron regenerans Manza	-		18
Calliarthron tuberculosum (Post.&Rupr.)Daws.	W	I	3,13,14,15
Callithamnion biseriatum Kyl.	W		2,15

Callithamnion pikeanum Harv.	N	I	3
Callithamnion rupicolum Anders. Fig. 10.	S	I	3,14
Callophyllis sp.	-	I	3
Callophyllis flabellulata Harv.	W	S	15,16
Callophyllis heanophylla Setch.	N	S	9,15,16
Callophyllis stenophylla Setch.	-		4
Callophyllis violacea J.Ag.	W	I,S	3,13,15,16
Carpopeltis bushiae (Farl.)Kyl.	S	I	13,14
Carpopeltis divaricata [?]	-	I	13,14
Centroceras clavulatum (C.Ag.) Mont. Fig. 11.	S	I	3
Ceramium sp.	-	I,S	3,13,14,16
Ceramium californicum J.Ag. Fig. 12.	W	I	3
Ceramium caudatum S. & G. Fig. 13.	S	I	3
Ceramium codicola J.Ag.	W	I,S	3,14,15,16
Ceramium eatonianum (Farl.)DeToni. Fig. 14.	W	I,S	3,13,14
Ceramium gardneri Kyl.	N	S	9,15,16
Ceramium pacificum (Coll.)Kyl.	W	S	15,16
Ceramium personatum S. & G.	-	S	16
Ceramium procumbens S. & G.	S	S	2,15,16
Ceramium sinicola S. & G.	S	I,S	3,14,15,16
Ceramium viscainoense Daws.	-	I	13,14
Ceramium zacae S.& G.	W	I	13
Chondria californica (Coll.)Kyl.	S	I,S	2,3,13,14, 15,16
Corallina sp.	-	I	3
Corallina officinalis var. chilensis (Dec.)Kütz.	W	I,S	3,10,13,14

Corallina pinnatifolia (Manza)Daws.	S		5
Corallina vancouveriensis Yendo	W	I	3,13,14
Cryptonemia angustata (S. & G.)Daws.	W	I	15,16
Cryptonemia borealis Kyl.	W	S	15,16
Cryptonemia obovata J. Ag.	W	S	15,16
Cryptopleura sp.	-	I	3
Cryptopleura corallinara (Nott.)Gardn.	W	I,S	3,13,15,16
Cryptopleura crispa Kyl.	S	I,S	13,14,15,16
Cryptopleura imbricata Daws. (?)	-		7
Cryptopleura lobulifera (J.Ag.)Kyl.	W	I	3,4,13,14, 15
Cryptopleura violacea (J.Ag.)Kyl.	W	I	3
Cumagloia andersonii (Farl.)S.& G.	W	I	3,13,14
Dasya sinicola (S.& G.)Daws.	S	S	9
Dermatolithon sp.	-	S	16
Endocladia muricata (Post.& Rupr.)J.Ag.	W	I	3,13,14
Erythrocystis saccata (J.Ag.)Silva	W	I	3,13,14
Erytrotrichia sp. Fig. 16.	-	I	3
Farlowia conferta (Setch.)Abb.	N	I	3
Fauchea sp.	-	S	16
Fauchea laciniata J.Ag.	W	I,S	3,9,10
Fosliella hubbsii Daws. [?]	-		4
Gastroclonium subarticulatum(Turner)KUtz. [G. coulteri (Harv.)Kyl.]	W	I	3,13,14
Gelidiocolax mammilata Fan & Papenf.	S	S	15,16
Gelidium sp.	-	S	16
Gelidium coulteri Harv.	W	I	3,13,14
Gelidium nudifrons Gardn.	S	I,S	3,10

Gelidium purpurascens Gardn.	W	I	3,13,14
Gelidium pusillum (Stackh.) Le Jol	W	I	3,13
Gelidium robustum (Gardn.) Hollenb. & Abb.	W	I,S	3,9,10,13 14,15,16
Gigartina sp.	-	S	10,16
Gigartina canaliculata Harv.	W	I	3,13,14
Gigartina corymbifera (Kütz.) J. Ag.	W	S	10
Gigartina exasperata Harv. & Bail.	W	I	3
Gigartina harveyana (Kütz.) S. & G.	W	I,S	3,13,14,15,16
Gigartina leptorhynchos J. Ag.	S	I	3,13,14
Gigartina spinosa (Kütz.) Harv. [G. armata J.Ag.]	S	I,S	3,13,14,15
Gigartina volans (C.Ag.) J. Ag.	W	I	3
Gloiosiphonia sp.	-	I	13
Goniotrichum sp.	-	S	16
Gracilaria sp.	-	S	16
Gracilaria lemaneiformis (Bory.) W. Boss. [G. sjoestedtii Kyl.]	W	S	15,16
Gracilaria pacifica Abb. [G. verrucosa (Huds.)Papenf.]	W	I	3
Gracilaria papenfussii Abb. [G. andersonii (Grun.) Kyl.]	S	I	3,13,14
Gracilaria robusta Setch.	N	S	2,15,16
Gracilariophila oryzoides Setch. & Wils.	W	I	3
Grateloupia sp.	-	I	13,14
Grateloupia doryphora (Mont.) Howe	W	I	3,14
Grateloupia prolongata J. Ag.	S	I	13
Gymnogongrus sp.	-	I	3,16
Gymnogongrus leptophyllus J. Ag.	W	I	3
Gymnogongrus platyphyllus Gardn.	W	I,S	3,14,15,16

Gymnothamnion elegans (C.Ag.)J.Ag. Fig. 18.	S	I	3
Haematocelis zonalis Daws.& Neush.	S		2,15
Haliptylon gracile (Lamour.)Johans.	S	I	3,5,15
Halymenia californica Smith & Hollenb.	W	S	15,16
Halymenia hollenbergii Abb.	S	S	1,2,15
Herposiphonia sp.	-	I,S	16
Herposiphonia littoralis Hollenb.	S	I	13,14
Herposiphonia plumosa [?]	-	S	16
Herposiphonia plumula (J.Ag.)Hollenb.	W	I,S	3,9,10,13 14,15
Herposiphonia tenella f. secunda (C.Ag.) Hollenb.	S	I	13
Herposiphonia verticillata (Harv.)Kyl.	W	I	3,13,15
Heterosiphonia erecta Gardn.	W	I,S	3,15,16
Heterosiphonia japonica Yendo [H. densiuscula Kyl.]	W	S	15,16
Holmesia californica (Daws.)Daws.	W		7
Hydrolithon decipiens (Fosl.)Adey	W	I	13
Hypnea valentiae (Turn.) Mont.	S	I	3
Iridaea cordata (Turn.)Bory.	W	I	3,13,14
Iridaea flaccida (S. & G.) Silva	W	I	3
Iridaea heterocarpa Post.& Rupr.	N	I	3
Iridaea lineare (S. & G.) Kyl.	N	I	3
Janczewskia gardneri Setch.& Guerns.	W	I,S	3,15,16
Jania tenella (Kütz.)Grun.	S	I	13
Kallymenia pacifica Kyl.	S	I	15,16
Laurencia sp.	-	I	3
Laurencia lajolla Daws.	S	I	3,13

Laurencia masonii S.& G.	S	I	13,14
Laurencia pacifica Kyl.	W	I	3,13,14
Laurencia sinicola S.& G.	S	I	2,14,15
Laurencia spectabilis Post.& Rupr.	W	I,S	3,9,13,14
Laurencia splendens Hollenb.	W	I,S	3,13,14,15 16
Laurencia subopposita (J.Ag.)Setch.	W	I	13
Leptocladia binghamiae J.Ag.	S	I,S	3,16
Lithophyllum proboscideum (Fosl.)Fosl.	W	I	13
Lithothamnium volcanum Daws.	S	S	2,6,15
Lithothrix aspergillum Gray	W	I,S	3,9,10,13, 14,15,16
Mastocarpus papillatus (C.Ag.) J. Ag. [Gigartina papillata (C.Ag.) J. Ag.]	N	I	3,13,14
Melobesia mediocris (Fosl.)Setch.& Mason	W	I	3,13,14
Microcladia coulteri Harv.	W	I	3,13,14
Murrayellopsis dawsonii Post.	W	S	15,16
Myriogramme caespitosa Daws.	S		2,15
Nemalion helminthoides (Vell.)Batt.	W	I	3,13,14
Neoptilota hypnoides (Harv.) Kyl.	N	I	3
Nienburgia andersoniana (J.Ag.)Kyl.	W	I,S	3,9,10,14, 15,16
Nitophyllum hollenbergii (Kyl.)Abb. [Myriogramme hollenbergii Kyl.]	W	S	15,16
Odonthalia floccosa (Esp.)Falk.	N	I	3
Ophidocladus simpliciusculus (Cr.& Cr.)Falk.	S	I	13
Opuntiella californica (Farl.)Kyl.	W	S	10
Petrocelis franciscana S.& G.	W	I	13
Petrocelis middendorffii	W	I	14
Peyssonelia meridionalis Hollenb.& Abb.	N	S	15,16

Peyssonnelia sp.	-	I	13
Phycodrys sp.	-	S	16
Phycodrys isabelliae R.Norr.& Wynne	N	S	2,15
Phycodrys profunda Daws.	W		15
Phycodrys setchellii Skottsb.	W	I	14,15
Phycodrys simplex Daws.	-	S	16
Phyllophora sp. [?]	-	S	16
Platysiphonia clevelandii (Farl.)Papenf.	W	S	15,16
Platythamnion sp.	-	S	16
Platythamnion heteromorphum (J.Ag.)J.Ag.	W		15
Platythamnion pectinatum Kyl.	W	S	15,16
Platythamnion recurvatum Woll. Fig. 19.	N	I	3
Platythamnion villosum Kyl.	W	S	9
Pleonosporium vancouverianum (J.Ag.)J.Ag. Fig. 20.	WD	I,S	3,9,15
Plocamium cartilagineum (L.)Dix. [P. coccineum var. pacificum (Kyl.) Daws.]	WD	I,S	3,10,13, 15,16
Plocamium violaceum Farl.	WD	I	3,13,14
Pogonophorella californica (J.Ag.)Silva	W	I	3
Polyneura latissima (Harv.)Kyl.	W	S	15,16
Polysiphonia sp.	-	I,S	3,13,14,16
Polysiphonia acuminata Gardn.	W	I	3,13,14,15
Polysiphonia brodiaei (Dillw.) Spreng.	N	I	3
Polysiphonia flaccidissima Hollenb.	S	I	13
Polysiphonia hendryi Gard. Fig. 21.	W	I	3,13,14
Polysiphonia pacifica Hollenbg. var. delicatula Hollenbg. Fig. 22.	W	I,S	3,9,16 15
Polysiphonia paniculata Mont. Fig. 23	W	I,S	3,15,16

Polysiphonia savatieri Harv.	W	I	3
Polysiphonia scopulorum var. villum (J. Ag.) Hollenb. Fig. 24.	W	I	3
Polysiphonia simplex Hollenb.	S	I	3,13
Porphyra perforata J.Ag.	W	I	3,13,14
Porphyrella californica Hollenb.	S	I	2,11,15
Prionitis australis (J.Ag.)J.Ag.	N	S	16
Prionitis cornea (Okam.)Daws.	S	I	13
Prionitis lanceolata (Harv.)Harv.	W	I	3,13,14
Prionitis lyallii Harv.	W	I	3
Pseudolithoderma nigra Hollenb.	S	I	13
Pterochondria woodii (Harv.)Hollenb. Fig. 25.	W	I,S	3,15,16
Pterocladia sp.	-	S	16
Pterocladia calloglossoides (Howe)Daws.	S	S	15,16
Pterocladia capillacea (Gmel.)Born.& Thur. [P. pyramidale (Gardn.)Daws.]	S	I,S	3,9,13,15, 16
Pterosiphonia baileyi (Harv.)Falk.	W	I,S	3,13,14,15, 16
Pterosiphonia dendroidea (Mont.)Falk. Fig. 26.	W	I,S	3,9,10,13, 14,15
Ptilothamnionopsis lejolisea (Farl.)Dix	W	I	3
Pugetia fragilissima Kyl.	N	I	15,16
Rhodoglossum affine (Harv.)Kyl.	W	I	3,13,14
Rhodoglossum californicum (J.Ag.)Abb. [R. americanium Kyl.]	W	S	16
Rhodoptilum plumosum (Harv.& Bail.)Kyl. [R. densum (Smith)Daws.]	W	S	15,16
Rhodymenia sp.	-	S	16
Rhodymenia arboresens Daws.	S	S	15

Rhodymenia californica Kyl.	W	I,S	3,9,10,14, 16
Rhodymenia pacifica Kyl.	W	I,S	3,10,13,14 15,16
Rhodymenia rhizoides Daws.	W	S	15,16
Sarcodiotheca furcata (S.& G.)Kyl. [S. tenuis]	W	S	2,15,16
Sarcodiotheca gaudichaudii (Mont.) Gabriel. [Agardhiella coulteri (Harv.)Setch.] [Agardhiella tenera Daws.] [Neoagardhiella baileyi (Kütz.)Wynne & Tayl.]	W	I,S 16	3,9,14,15,
Scagelia pylaisaei (Mont.) Wynne [S. occidentale (Kyl.) Woll.] [Antithamnion occidentale Kyl.]	W	S	15,16
Schimmelmannia plumosa (Setch.)Abb.	N	I	3
Schizymenia dawsonii Abb.	S	S	10
Schizymenia pacifica (Kyl.)Kyl.	W	I	3,14
Scinaia confusa (Setch.) Huisman [Gloiophloea confusa Setch.] [Pseudogloiophloea confusa (Setch.) Levr.]	W	I	3
Smithora naiadum (Anders.)Hollenb. [Porphyra naiadum Anders.]	W	I,S	3,5,14,15, 16
Sorella delicatula (Gardn.)Hollenb.	W	I	3
Sorella pinnata Hollenb.	S		15
Stenogramma interrupta (C.Ag.)Mont.	W	S	15,16
Tenarea canescens (Foslie)Adey [Dermatolithon canescens] ID. questioned by (2)	-		6
Tenarea dispar (Fosl.)Adey	W	I	13
Tiffaniella snyderiae (Farl.)Abb.	W	I,S	3,9,10,14, 15,16
Weeksia templetonii S. & G. [Halymenia templetonii S. & G.)Abb.]	S	S	5,15

DIVISION ANGIOSPERMAE (Flowering Plants)

Phyllospadix scouleri Hook.	W	I	3,13,14
Phyllospadix torreyi Wats.	W	I	3
Zostera marina L.	W	S	16

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